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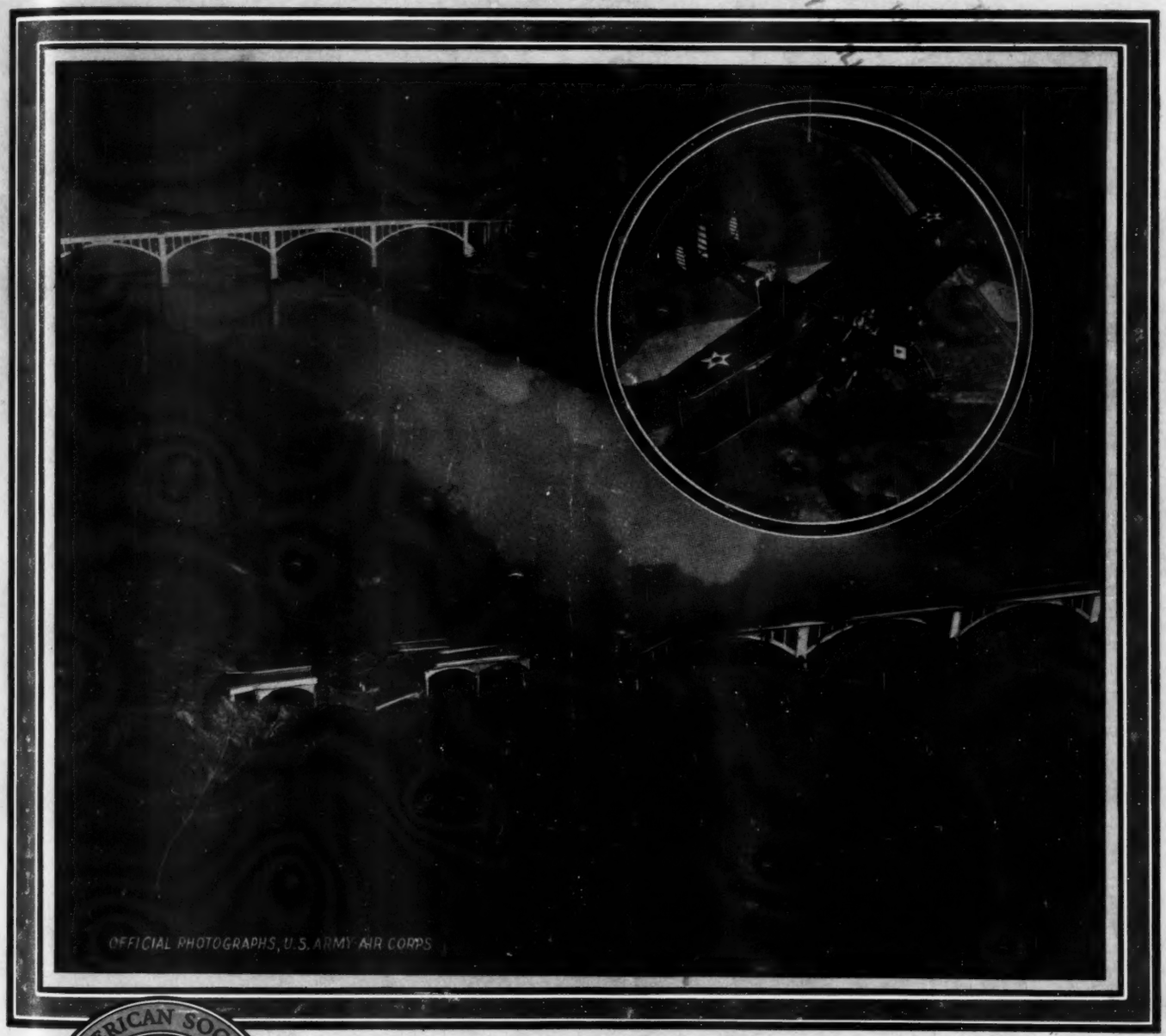
MECHANICAL ENGINEERING



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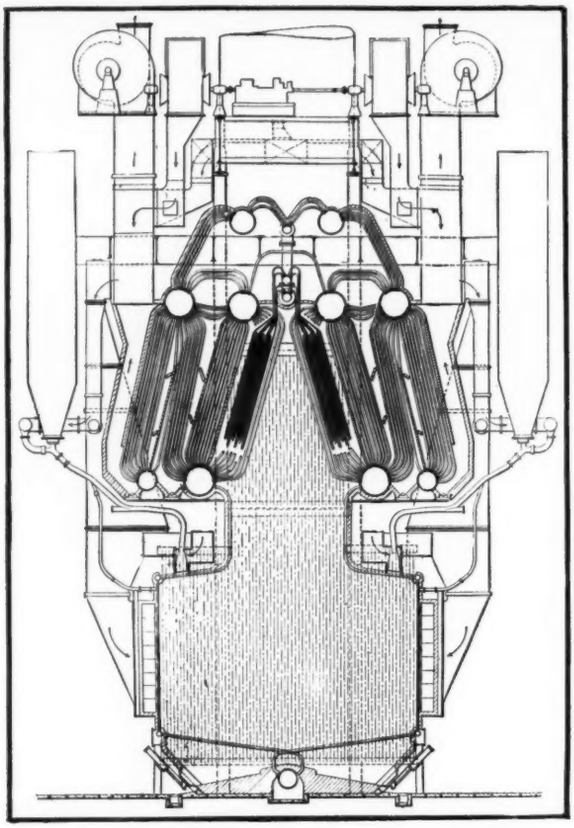
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

March 1930



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This Month's Cover is a view of the Pee Dee River Bridge showing the extent of damage caused by the dropping of an 1100-lb. bomb on December 24, 1929.

MECHANICAL ENGINEERING

Volume 52 March, 1930 No. 3

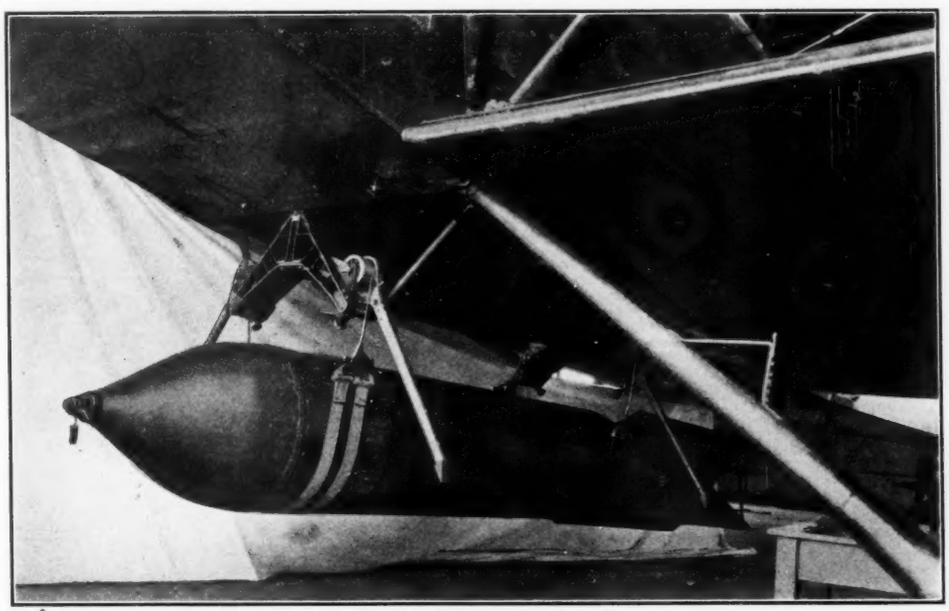
The Military Value of Aviation

A Discussion of Aircraft as Affecting Strategy and the Tactics of Warfare

By LEON CAMMEN,[1] NEW YORK, N. Y.

WHILE aviation was of considerable moment during the World War, its true value had not at that time been established because of the comparatively small number of planes used, and further because it was only toward the end of the conflict that really effective types of heavier-than-air craft began to appear. Moreover anti-aircraft defenses were extremely crude at that time, and therefore of little effect.

Since the war, however, aircraft have participated in a number of military maneuvers carried out by land and naval forces of this and foreign countries. One such maneuver of a very spectacular nature was the sinking of a former German battleship by air bombs in Hampton Roads some seven years ago.



External Bomb Rack of Plane, Showing 2000-Lb. Bomb in Hoist

The tremendous development of aviation which has taken place since the World War makes it now possible to determine in a general way the main strategic and tactical problems which the introduction of aircraft into warfare may serve to solve or modify in character. The one fundamental fact which has to be considered as a result of this use of aircraft, is that war, which hitherto has always been a two-dimensional proposition, has suddenly been projected into the third dimension. The defense line, which in the last war was a line of trenches extending from the Swiss frontier to the sea and bristling with bayonets and machine guns, has suddenly lost its importance as a means of protecting the territory back of it. No longer, for example, may a Fatherland feel secure because of the firm stand of the watch on its Rhine, for with the advent of aircraft that form of protection utterly fails to protect. This means that we are now experiencing the most radical change in methods of carrying on warfare that has occurred since the day when our remote ancestors began to employ clubs in place of their claws and fists.

AIRCRAFT IN LAND WARFARE

The purposes for which aircraft may be used in land warfare may be classified as follows:

1 Observation near the battle line and artillery spotting.

2 Observation back of the battle line, deep into enemy territory.

3 Bombing and machine-gun firing.

4 Raids into enemy territory.

5 Protection against enemy aircraft, as well as general service such as military transportation.

1—Observation Near the Battle Line and Artillery Spotting

These were two of the main purposes for which aircraft were used in the World War, but they would be much more difficult problems now because of the development of very superior anti-aircraft equipment and also because of the more extensive employment of machine and sub-machine guns. To be safe in daytime a plane will have to keep to a height of not less than 15,000 ft., and may possibly have to go even higher. From such a height, ground observation is comparatively difficult, particularly if the front is an active one and any considerable haze is created by artillery firing. On the other hand, however, the development of wireless will facilitate communication between the plane and the ground station. In Europe the

[1] Associate Editor, Mechanical Engineering.

tendency is apparently toward the development of a special type of observation plane carrying a pilot and observer. This plane will not hover over the battlefield like a kite but will sweep over it at a comparatively low altitude, flying at such a tremendous speed, say, of the order of 250 miles an hour, that only a chance shot could hit it. The observer will have only fractions of a second to note what is happening on the ground, but will be specially trained so that he will be able to bring back with him a clear mental picture of what he saw. Moreover, since the World War aerial photography has been developed to the point where there would be no trouble now in flying over, say, a trench system and returning with views covering its complete topography.

2—Observation Back of the Battle Line, Deep Into Enemy Territory

At the beginning of the World War this was not done at all because the necessary matériel was lacking. As time went on, however, an increasingly important use was made of such observation, but at no time was it carried on on a sufficient scale to obtain a complete picture of all that was going on back of the front lines. It is, however, of the very greatest importance for practical purposes, as obviously a large movement of troops and war matériel toward a certain section of the battlefield will clearly indicate that something is going to happen soon in that particular location. If the allies had had such information, say, three weeks before the attack on Verdun started, they would not have been caught so unprepared on that important sector of the battle front. To make such observation effective it is necessary that it shall be carried on systematically and on a sufficiently large scale to make it certain that no part of the territory, say, 300 miles back of the fighting front, has been left a blind spot. Unless this is done, the information is apt to prove misleading and create a deceptive feeling of safety where no safety really exists. This means, however, that a considerable number of airplanes will have to be engaged in this particular service. Whether or not it can be undertaken will then depend on the availability of the planes, it being assumed that it is easier to provide the personnel of pilots and observers than to produce planes (which is probably true up to a certain point).

Plane Equipped With Machine Gun

While a good deal of effort is being directed toward the development of such a system of observation, particularly in Europe, next to nothing is being published thereon for obvious reasons. In particular, it is not known what is being done in the way of constructing planes specially adapted for this service and what type of planes would seem to be best to use. The indications are, however, that for such observation far in the rear of the enemy's lines, a fairly fast plane with the lightest form of armament will be used. As the plane will have to have a cruising range of about 800 miles, the weight of fuel will be considerable. It will therefore be necessary to equip the plane so that it can fight in a chance encounter with a single machine, but it will have to be sacrificed if it encounters an enemy squadron. It will have to have an average speed of about 150 miles per hour, and a ceiling of some 20,000 ft. at two-thirds load. That the engine will have to be equipped with some form of muffler appears fairly certain. Although an engine muffler does not make a plane noiseless, it does help in that the plane attracts less attention and its identity as an enemy plane is less easily established. It may be mentioned in this connection that with present listening devices certain types of engines can be easily recognized by the noise of their exhaust. The noises produced by the propeller and wires, however, are more difficult to identify as characteristic of a given type of plane.

The purpose of this observation far back into enemy territory is primarily to detect military activity by the intensified movement of trains along certain lines, automobiles along certain roads, transfer of military forces from one part of the country to another, entrainment of men, and, when possible, carriage of heavy machinery. Information as to each of these factors taken in conjunction with such other information as the general headquarters may have is always of value and may prove to be of unusual importance under certain conditions.

3—Bombing and Machine-Gun Firing

The use of machine guns from an airplane against ground troops became increasingly common toward the end of the World War. To what extent they may now be used is by no means certain. On the one hand there has been of course a great improvement in airplanes and machine guns. On the other hand, however, there has been a tremendous improvement in anti-air-

craft weapons, and it is very doubtful whether today an airplane could sweep over a well-equipped land force, machine-gun them, and get away safely. There are still, however, some possibilities left. For example, an airplane of the high-speed observation type can descend very rapidly over a land force and let fall a smoke screen. A heavier plane equipped with machine guns can then follow and attack the ground force through the smoke screen, using to determine its direction and location apparatus similar to that which has been developed for blind flying by Bougerie in France. Another possibility is that of attacking land forces from the air at night.

When it comes to bombing, however, the airplane can render some very outstanding services. Bombing from the air may be divided into three classes. In the first, bombing against general troops, either high explosives or war-gas bombs may be used. In this way not only can a considerable amount of actual damage be done, but the morale of the bombed troops may be affected. Such bombing is particularly effective against transports directly behind the battle line, because it permits disorganizing this service quite easily, not only by direct attack but by blowing up the roads themselves.

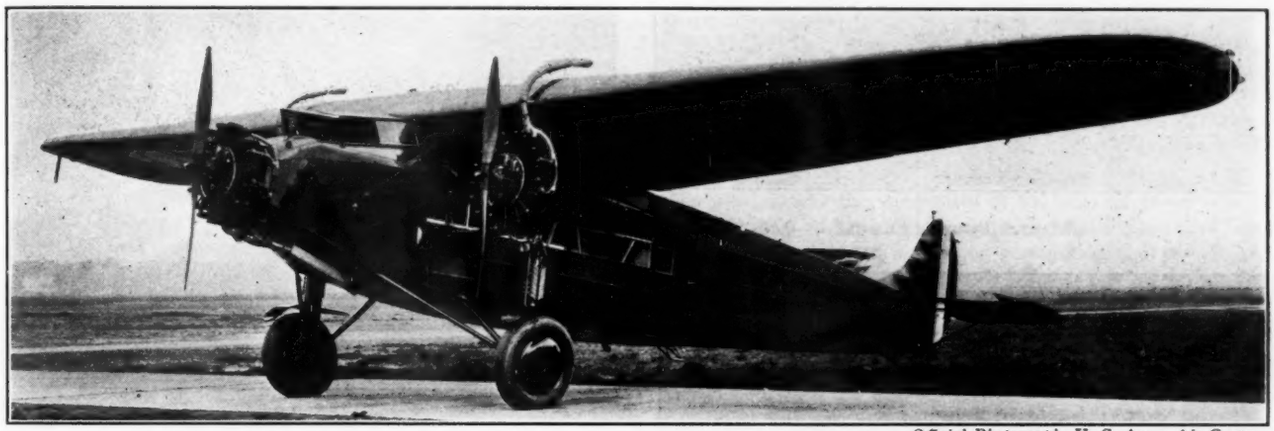
The second use of bombing is by attacking special objectives such as ammunition dumps, aircraft fields, important railway junctions, bridges, factories, etc. The bombarding of trains back of the fighting line from the air can also be achieved comparatively easily with present equipment, and with excellent results from many points of view. One advantage of bombarding special objectives back of the enemy's lines lies in the fact that it makes it necessary for the enemy to maintain an aerial defense of every important objective, which ties up so tremendous a number of his aircraft as to greatly reduce the efficiency of their employment offensively.

In this connection an important problem to be solved will be the selection of the type of bomb—that is, whether high-explosive or gas bombs should be used. If, for example, a steel mill is being bombed it is of course possible once in a while to hit such a vital part as a blast furnace, which, if once destroyed, cannot be easily rebuilt. In general, however, the damage can be comparatively easily repaired. On the other hand, if such a steel mill is bombed by shells containing a considerable amount of a persistent toxic war material such as mustard gas, the actual damage done may not be great but it will greatly disorganize the operation of the mill and in this way cause more damage than would the destruction of parts of the mill of secondary importance. Bombardment of a railroad station by gas bombs would also probably do more damage than bombardment by high-explosive shells. However, in this connection a good deal depends on the character of the persistent toxic materials that military chemistry will be able to evolve before the Next Time.

There is one more possibility of employment of aircraft which every one has in mind but which few care to discuss, and that is aircraft attack against civilian population at large. There is an undoubted element of horror involved in killing men, women, and children far back of the fighting line. This is a relic of the medieval feeling of chivalry under which only an armed force could be attacked. It also accords with the general precepts of civilization, under which fighting should be confined to the fighting forces proper. But it is well to look facts in the face. The main reason in the past for sparing the so-called non-combatant population was that, presumably, it was outside of the fighting zone. Cities within range of guns have always been bombarded without restriction. If its civilian population was not evacuated, that was a city's own misfortune, and a matter for which its governing body was responsible. There was no especial outcry against the Germans when their guns bombarded Paris, even though the city was located some sixty miles behind the fighting line. Apparently the employment of guns having an enormous range of fire justifies attacking whatever can be reached thereby. One-hundred-mile guns are already in existence, and probably within the next year or two distances as great as 150 miles will be attained by using for gun material some of the modern alloy steels which will withstand enormous chamber pressures. Now if a town one hundred to one hundred and fifty miles back of the fighting line can be legitimately bombarded by the enemy with gun shells, notwithstanding the fact that it is full of non-combatants, including women and children, there is apparently no special reason why the same town should not be bombarded from the air; and if one town back of the fighting line can be legitimately bombarded from the air, there is no reason why another should be excepted.

Bombardment of the general civilian population by high-explosive bombs as carried out on a small scale against Paris and particularly London by the Germans can cause a considerable amount of damage, but hardly enough to justify the necessary expenditure in men and materials and compensate for the resentment that such a bombardment will create. On the other hand, the destruction of such specific objects as central light and power stations, and particularly water works, may have an important effect in disorganizing the life of the population and thus reducing the power of the "man behind the man behind the gun."

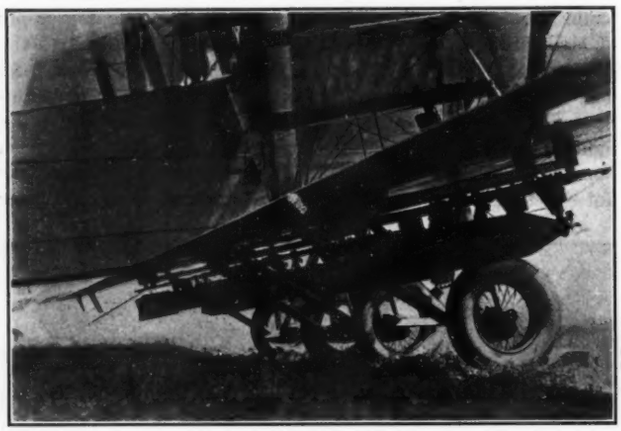
When it comes to large cities, an attack by persistent poison



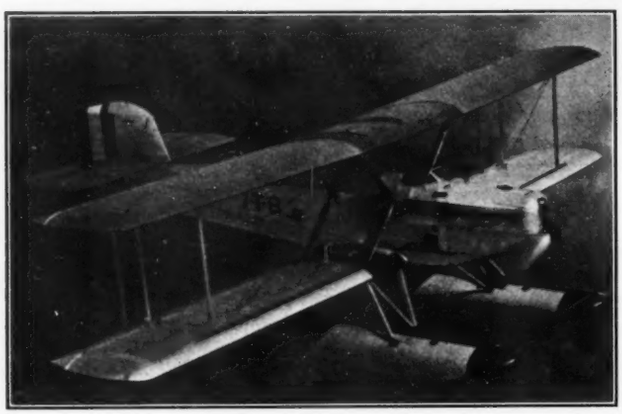
Official Photograph, U. S. Army Air Corps

MILITARY TRANSPORT OR CARGO AIRPLANE

gases, which do not even need to be toxic to the lethal stage, may prove to be extremely effective in disorganizing the life of the municipality and require concentration of police and military forces to control the situation thus created. Imagine, for example, New York to be bombarded by heavy tear gas. None need be killed by this gas directly, but it will disorganize ground traffic first of all and will create such confusion as will make it impossible to transact business. The transfer of freight be-



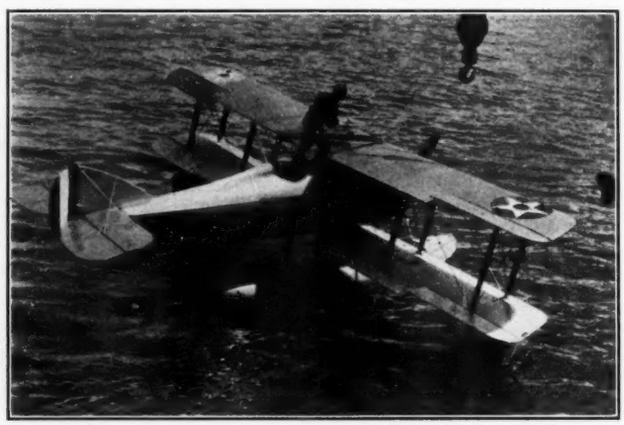
MARTIN BOMBER PLANE



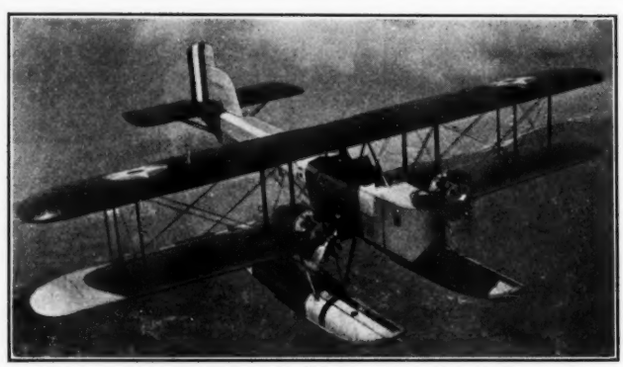
TORPEDOPLANE

tween terminals, many of which may be of a military nature, will be broken down or retarded. Large numbers of police will be required to untangle the traffic snarls, which will make the protection of objects of a military character more difficult and create especially easy opportunities for the work of enemy spies and for sabotage. Then in a little while the gases will filter down into the subways, and few worse things could happen to a city like New York in wartime than to have the subways and river tubes put out of business or even their traffic delayed. In this way a few tons of the right sort of war gas can cause a tremendous amount of trouble and upset military transportation plans and the morale of the people to a degree that nothing else can do. It is particularly effective in bringing the sense of danger and horror to the civilian population far back of the fighting line proper. It is a significant fact that as a whole the non-combatant civilian population does not know enough of the horrors of warfare to realize what is going on. Not only that, but certain classes of non-combatants actually live better and make more money during a war than they did before. While therefore every one expresses aloud horror at the murder of his fellow-men, the cynical are inclined to feel that there may be a not unimportant group of non-combatant population who in their innermost hearts are not entirely averse to having this go on so long as their own safety is not affected. However, let the war be carried directly to the non-combatant population and let it be shown that there is safety for no one, just or unjust, and a longing for peace will develop among them such as might not be brought about under any other conditions. Nothing will discourage the warlike spirit like being within the range of guns, and many a boastful citizen willing to fight to the last, will soon change his mind once he comes to realize that he may be the first man to fall. From this point of view, air attack upon non-combatants may be effective in creating a spirit of conciliation among nations that otherwise would generally be entirely absent.

Many statements have been made as to the possible effect



HOISTING PLANE ABOARD SHIP



ANOTHER TORPEDOPLANE

of bombardment of cities from the air by so-called poison gases, some claiming that whole nations could be wiped out by this method, while others expect it to be effective to only a very limited degree. Essentially it is a matter of quantity. Cities like New York, which would have to be bombarded from the sea, are comparatively safe, because the distances would be such as to make the amount of gas or toxic liquid that could be dropped on to the city small. If, however, war broke out again, say, between France and Germany, each country would be in a position to drench every night the big cities of the other with poison gas, and even with the gases used in the last war it would be perfectly possible to make cities uninhabitable after a couple of weeks of such bombardment because of the cumulative effect of bombardment with persistent materials. Where a city takes

water from open reservoirs, as is the case, for example, with New York, it would be a comparatively simple matter to drop every night a few bombs filled with either poisonous or nauseating materials, such as chlorpicrin or butyl mercaptan, and thus make the water undrinkable. Several materials with a lead base are also known which have the same effect on water. While therefore, at least with our present means, the wiping out of civilian populations of whole cities is possible only in isolated instances where the conditions of operation are particularly favorable, attack from the air makes it possible to introduce such disturbances as would completely paralyze urban life, and there is no question that the ability to bring this about would be of enormous military value.

4—Raids Into Enemy Territory

This is something that was never attempted during the World War, except in the matter of transporting spies, but has been tried without outstanding success on several occasions since. Let us assume that war breaks out again between France and Germany. The French send out five to ten airplanes which land some two hundred miles back of the fighting line in Germany and discharge a hundred picked men fully armed and specially equipped, whereupon the planes fly back home. The men thus landed consist of picked engineer forces fully armed. They attack certain specified objectives such as large power plants, blow up bridges, cut down electric wires; then perhaps take possession of a garage, commandeer automobiles, and repeat the same performance twenty miles away. In one night a picked force of five score men equipped with machine guns and high explosives can do a surprising amount of damage far back of the front where there are no military forces to stop them. At the end of the raid the men simply surrender and permit themselves to become prisoners. As they would operate in uniforms with their country's flag fully displayed and under the command of uniformed officers, they would have to be treated as prisoners of war and not as spies. And the retirement from military activity of such a small number of men would not be too big a price to pay for the objective thus attained.

This form of warfare, novel as it is, is of particular importance because, in addition to the destruction which a few men thus sent are capable of effecting, it has the result of making it imperative to maintain strong defense forces for hundreds of miles back of the fighting line, obviously weakening the active forces. Unless this is done, not only will raids of the character described become immensely more destructive, but a strong incentive will be created for the enemy to devote more attention to attack back of the line—and *no army can afford to have an unprotected rear which the enemy is at liberty to attack at will.*

NAVAL WARFARE

While there is reason to believe that naval warfare will be even more thoroughly revolutionized by the introduction of aircraft as a fighting element, comparatively little is being said about it. In fact, to an outsider it would appear as if there is a deliberate conspiracy of silence. Apparently every nation has something up its sleeve, and feels that the least said about it the better.

We have referred before to the spectacular test made for the purpose of determining the superiority or inferiority of the air bomb as against the staying qualities of the battleship. In this, under the conditions of a maneuver, the airplanes had no trouble in sinking the surface vessels. Of course the latter were not allowed to fight back, so that to that extent the test was not conclusive. Since then, however, the cruising range of airplanes has increased tremendously and considerable progress has been made in the way of sighting and aiming bombs. And yet not only has there been no other test made of the respective fighting powers of airplanes and battleships when opposed to each other since 1922, but there is apparently no desire among the interested parties to make one.

The facts, however, are as follows: With the present development of torpedo boats and submarines, no battleship or large cruiser can operate without the protection of a screen of small, fast vessels such as small cruisers and torpedo-boat destroyers. Even assuming that the battleship and large cruiser because of their heavy armament and the use of waterproof bulkheads and "blisters" are safe against bombs from the air, there is no question about the very great vulnerability of such vessels as torpedo-boat destroyers, even when small bombs are used. What is more, the small cruiser and destroyer roll and pitch too much to permit effective use of anti-aircraft guns. It would appear, therefore, that in any but the clearest weather, particularly in foggy weather, at dusk, or in the night, aircraft would have no trouble whatsoever in sinking or putting out of commission the smaller craft forming the screen about the vessels of the line, leaving them either to be attacked by submarines and destroyers later on, or destroying them in their turn by attack from the air. A battleship squadron without its protective screen and without such auxiliary units as colliers would be truly helpless—and aircraft are unquestionably capable of destroying the screen.

To what extent the willingness of the ranking powers to reduce that part of their fleets comprising battleships and large cruisers is the result of a growing recognition that within the next few years these vessels may become obsolete in any case, it would be difficult to say. The fact is, however, that at least among European nations a vigorous effort is being made to develop types of aircraft capable of operating for long distances away from shore or from a mother ship.

Aircraft can be used against battleships in ways other than by hitting the latter with demolition bombs. In the first place, airplanes can attack surface vessels with incendiary bombs—for example, those of the white phosphorus type. Such bombs are comparatively small, and therefore a plane can carry a substantial number of them, so that while aiming is as difficult as in the case of large bombs, the probable percentage of hits is greater; and when the bombs strike the vessel they scatter over a wide area and cause painful burns to the men, in addition to starting fires wherever possible. Furthermore, airplanes can cause a lot of trouble by using poison-gas bombs against surface vessels, particularly bombs containing toxic materials of the persistent type. A modern battleship has a wonderfully well-developed system of ventilation which effectively circulates air throughout the huge structure. If the vessel is hit, however, by a poison-gas shell this system of ventilation becomes a grave liability in that it carries the toxic material to every nook and cranny of the ship. The result is that unless the ship's personnel immediately don gas masks, there will be fatalities. Just how many ships of any navy carry a sufficient complement of masks for the entire crew, it would be difficult to say. Moreover, in no navy that the writer knows of are proper drills carried out with gas masks on, and at best the ship's personnel are not sufficiently well accustomed to their use to be able to function effectively under battle conditions. Further, to the writer's knowledge no special gas masks have been developed for the various types of services, and, for example, a telephone operator would be put to it if it became necessary for him to work in a gas mask. What is more, if the gas used is of a persistent type, such as mustard gas, it would be necessary either to cleanse the ship from end to end after every attack, which is not easy and perhaps not feasible, or else keep the men in gas masks for several days until the gas had been completely dispersed. This may

not sound so difficult on paper, but a man in a gas mask cannot eat, cannot drink, and, worst of all, cannot smoke.

The airplane has one further important means of annoying surface vessels, and that is by laying smoke screens. The speed of an airplane as compared with that of a battleship or cruiser is so great that it can easily dodge in and out of the vessel's course and lay smoke screens while so doing. Such a smoke screen presents a double danger. In the first place, the complete elimination of visibility is extremely dangerous to vessels operating in squadron formation. In the second place, it makes mine sweeping an exceedingly hazardous and uncertain operation, while on the other hand it facilitates greatly the work of enemy destroyers and submarines. Ships of a squadron that can be suddenly blinded at any given spot on the wide ocean are at best not healthy places for sojourn, and airplanes can effect this blinding process with scarcely any danger to themselves.

One reservation must be made to all that has been said above both as to army and navy warfare, and that is that very effective work without aircraft can be carried on only against an enemy who is not sufficiently equipped with aircraft himself. The best protection against aircraft attack is aircraft used either defensively or offensively, and the effectiveness of aircraft work depends largely on the extent to which the enemy's aircraft allow them to perform. Of course, the situation is largely the same as that between criminals and the police. Where the police are extremely efficient, crime is held down to a minimum. Where the criminals are efficient, however, even good police cannot prevent a large amount of crime, simply because the criminal selects the point where he will strike, while the police have to cover an enormous area for protection.

For example, an airplane can attack at night a battle squadron equipped with a very superior aircraft force, simply because the attacking plane can strike unexpectedly in the darkness and be off, perhaps having accomplished its purpose, long before the defense planes wake up to its presence. It is therefore fairly certain that a military force, be it on land or on water, can be protected from the air, at least to some extent, by adequate aircraft of its own, and it is probably just as certain that under modern conditions of warfare even a very superior land or naval force will be helpless before an otherwise greatly inferior enemy if the latter has sufficient control of the air.

As a means of preventing blockade running, aircraft has no equal. An airplane or a dirigible from the elevation that it can easily attain has an enormous range of vision, in addition to which, through its superior speed, it can patrol the ocean lanes in a way absolutely impossible for surface vessels. It can report by wireless the presence of any suspicious vessel, leaving it to be dealt with by the proper forces. It must not be forgotten in this connection that during the last war the German government claimed the right to sink vessels carrying contraband without making any provision for the safety of the crews, because, it claimed, submarines were incapable of doing so. While it gave up this contention in the so-called *Sussex* and *Lusitania* notes in so far as American vessels were concerned, it has never recognized the general principle as being wrong. It would therefore be merely an extension of this principle to sink enemy trading vessels by bombs from the air. This is a very horrible thing to think of, but in full accord with the savage principles of modern civilized warfare.

We have deliberately left out of consideration the question as to which of the functions indicated above would be performed by airplanes and which by dirigibles. Both types have their own important uses, and it will be principally the availability of dirigibles that will control their application. If only one or two are available, they would be too valuable to risk unnecessarily, and would be used only where absolutely needed.

In conclusion, it may be stated that even though the military airplane is still very far from having reached its full development, it has already become to all practical purposes the pivotal arm of modern fighting, and has changed methods of warfare in a more profound manner than anything since the invention of powder. And it must be clearly recognized that we are only on the threshold of this development and that uses that would be considered too fantastic to mention today will become practical and possible when, instead of the present thousands, hundreds of thousands of planes become available to the commanders of tomorrow. We have referred above to raids effected by companies of perhaps one hundred men carried in ten airplanes two or three hundred miles deep into the enemy's territory. Why only ten airplanes and not a hundred, and one hundred men and not five thousand? After all, the only reason why a fighting line exists at all in warfare is because it prevents the army of the enemy from invading the soil of the defender. But with a truly large number of airplanes available, running perhaps into hundreds of thousands, the battle line of today will be as inadequate for its purpose as would be a fence in preventing an eagle from flying away. We have already said that the introduction of aircraft is projecting warfare into three-dimensional space. However, those who are not afraid of looking a little into the future are already contemplating forms of warfare as unlike those of today as the World War was unlike the siege of Troy. A declaration of war at noon, half a million men in the air within three hours, and landed three hundred miles back of the enemy's frontier in another six hours! All that is necessary to do this is a sufficient number of airplanes. We have already planes capable of carrying up to 169 persons, and every plane that transports passengers, mail, and freight is capable of carrying soldiers, machine guns, and bombs.

One factor should be brought out whenever military aviation is being discussed. A plane used for the carriage of passengers or mails has to satisfy certain requirements as to speed, safety, etc., but so long as it passes these requirements it can be used, even though better planes are already in existence. This principle is entirely incorrect when applied to military aviation. Nothing but the best in its class should be used when it comes to warfare, and sending up a man in a plane known to be inferior to that of an adversary he may encounter is morally little short of deliberate murder. An analysis, for example, of the remarkable career of Baron von Richthofen, the German "ace," shows that most of his victories over the British were obtained when they were flying in such craft as the S. E., which, except for war hysteria, should never have been allowed to approach within a hundred miles of the front. When the British fliers began to be equipped with planes that looked more like what a military machine should be, Richthofen had to change his tactics, whereupon he was killed.

It has been repeatedly stated and is unquestionably true that any of the operations enumerated above can be carried on if one has either a preponderance in the air or at least an equal force. If the enemy completely controls the air, it will be he who will derive the full advantage of position in aviation. It is impossible to meet the enemy in the air if his planes are superior, and it is impossible to develop plane design under the stress of warfare, particularly as the next war, if there is to be a next one, will not last for years. It may therefore be stated with full confidence that the preponderance of success attained in research and development work in plane design in times of peace will definitely predetermine the outcome of any armed conflict that may take place in these days when war, from being an encounter between trained soldiers, has become a conflict between the scientific, engineering, and manufacturing forces of the combatants.

Stress Distribution and Plastic Flow in an Elastic Plate With a Circular Hole

By A. NADAI,[1] R. V. BAUD,[2] and A. M. WAHL,[3] PITTSBURGH, PA.

In this paper a calculation is made of the distribution of shearing stress in a plate of large width and having a circular hole, the plate being subjected either to tension, compression, or pure shear. This calculation is quantitatively checked up for the case of tension by photoelastic tests. Tests were made on compression-test specimens of steel and hard copper to illustrate the mode of yielding or plastic flow in a compression member with a hole. On the basis of the work done an explanation is offered for this experimentally observed mode of yielding. Conclusions are drawn regarding necessary factors of safety in compression or tension members having holes.

IN MACHINE construction, tension or compression members having holes are very frequently used. It has been noticed that yielding or plastic flow of such members takes place under certain conditions in two comparatively thin layers. These layers cross in the axis of the hole and form angles of about 45 deg. with the axis of tension, the angle depending on the material. The investigation described here was made chiefly at the Research Laboratories of the Westinghouse Electric & Manufacturing Company, and, it is believed, throws some light on the reason for this method of yielding.

The investigation consisted in calculating the distribution of the lines of constant maximum shear in an infinitely wide plate having a circular hole subjected to a uniform tension, the general equations of the theory of elasticity being employed. This calculation was quantitatively checked by a photoelastic test, and in this way it was shown that there are considerable areas extending from the hole at angles of about 50 deg. where the shearing stress is considerably higher than the average value, which would tend to explain, at least in part, the mode of yielding. Finally, steel and copper models having holes were subjected to a stress above the yield point to illustrate the manner in which yielding occurs in a compression or tension member made of ductile material.

Lines of Constant Maximum Shear in Plate With a Circular Hole and Under Tension

In order to calculate the lines of constant maximum shear in a plate of constant thickness with a circular hole and subjected to uniform tension or compression, the problem being considered two-dimensional, the following procedure was adopted. Referring to Fig. 1, consider a point P located in a thin plate having a hole of radius a. The polar coordinates of this point are r and ϕ. The plate is subjected to a uniform tensile stress of S lb. per sq. in. in the direction of the polar axis $\phi = 0$. For calculation of the stresses, Airy's stress function was used.[4] For the case of a plate with a hole, this function is:

$$F = \frac{S}{4}\left(r^2 - 2a^2 \log_e r - \frac{(r^2 - a^2)^2}{r^2}\cos 2\phi\right) \quad [1]$$

The stress components S_s, S_r, S_t may be obtained by the differentiation of this function; thus:

$$\text{Radial stress: } S_r = \frac{1}{r^2}\frac{\partial^2 F}{\partial \phi^2} + \frac{1}{r}\frac{\partial F}{\partial r}$$

$$\text{Tangential stress: } S_t = \frac{\partial^2 F}{\partial r^2}$$

$$\text{Shearing stress: } S_s = -\frac{\partial}{\partial r}\left(\frac{1}{r}\frac{\partial F}{\partial \phi}\right)$$

Carrying out this differentiation, the stress components become:

$$\text{Radial stress} = S_r = \frac{S}{2}\left[1 - \frac{a^2}{r^2} + \left(1 - \frac{4a^2}{r^2} + \frac{3a^4}{r^4}\right)\cos 2\phi\right] \quad [2]$$

$$\text{Tangential stress} = S_t = \frac{S}{2}\left[1 + \frac{a^2}{r^2} - \left(1 + \frac{3a^4}{r^4}\right)\cos 2\phi\right] \quad [3]$$

$$\text{Shearing stress} = S_s = \frac{S}{2}\left[-1 - \frac{2a^2}{r^2} + \frac{3a^4}{r^4}\right]\sin 2\phi \quad [4]$$

The maximum shearing stress is given by:[5]

$$(S_s)_{\max.} = \sqrt{\frac{(S_t - S_r)^2}{4} + (S_s)^2} \quad [5]$$

Using the values of S_t, S_r, and S_s given by [2], [3], and [4], we may get the following expression:

$$K = \frac{2(S_s)_{\max.}}{S} \quad [6]$$

which is a function of ϕ and a/r. The contour lines of this function are plotted in Fig. 2. For example, the contour line marked 1.1 is the locus of the points where the ratio K (Equation [6]) has the value 1.1.

Photoelastic Tests

To confirm these analytical results, tests with polarized light were made with a transparent model of bakelite 2 in. wide having a 0.32-in.-diameter hole located on its axis. By making a black-and-white photograph of the color fringes of the loaded model, the stress distribution as shown in Fig. 4 was obtained. The bands of equal darkness or brightness are isochromatics, or lines of constant color, i.e., lines of $2(S_s)_{\max.}$ = constant. The form of these lines agrees well with that of the contour lines given in Fig. 2, which is to be expected, since they represent in both cases the loci of points for which K = constant.

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[1] Graduate School, University of Pittsburgh; Research Department, Westinghouse Electric & Manufacturing Co. Mem. A.S.M.E.

[2] Research Department, Westinghouse Electric & Manufacturing Co.

[3] Research Department, Westinghouse Electric & Manufacturing Co. Jun. A.S.M.E.

[4] The stresses in a tension member in the form of a wide plate with a hole appear to have been first calculated by Kirsch, *Zeitschrift des Vereines deutscher Ingenieure*, July 16, 1898, p. 797.

[5] This follows from Mohr's circle diagram.

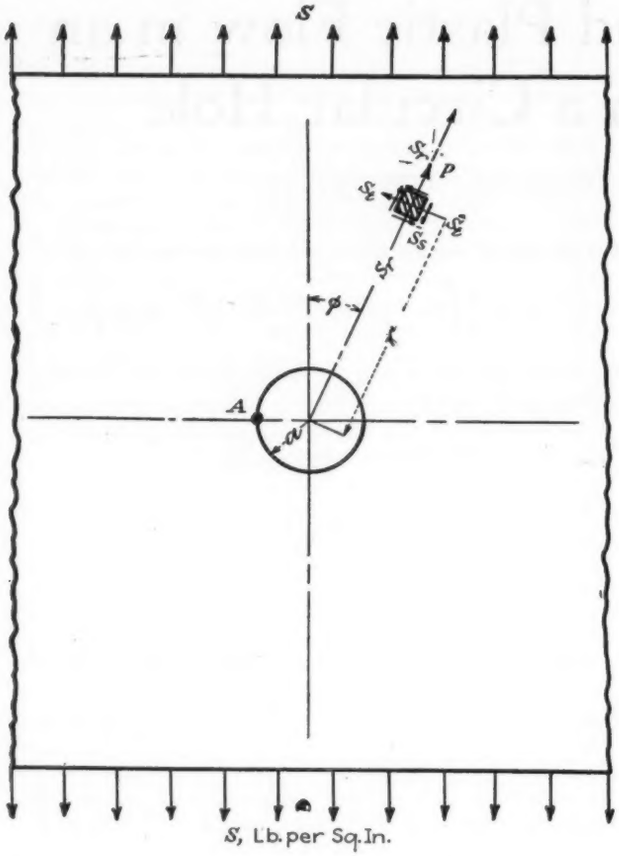


FIG. 1 PLATE WITH CIRCULAR HOLE AND UNDER TENSION

To make a quantitative check, the isochromatics as obtained from a colored and a black-and-white photograph were drawn, and in addition colored and black-and-white photographs were taken of a strip of bakelite subjected to bending. By matching the shades of the model with those of the strip in bending, the ratio K, as defined by Equation [6], was established for each isochromatic (see Fig. 3).

Fig. 5 shows the variation of the ratio K along the axis of tension, along an axis perpendicular to the axis of tension, and along an axis inclined at an angle of 45 deg. with the axis of tension. The full lines in the figure represent the calculated curves, while the points shown represent values found from

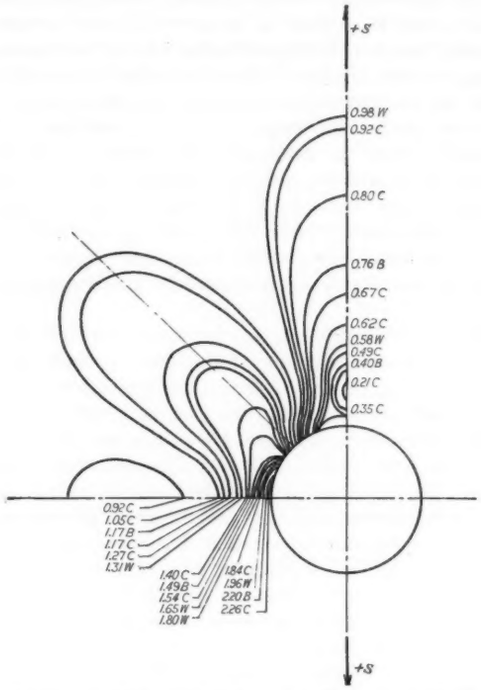


FIG. 3 LINES OF CONSTANT MAXIMUM SHEAR AS DETERMINED FROM PHOTOELASTIC TESTS

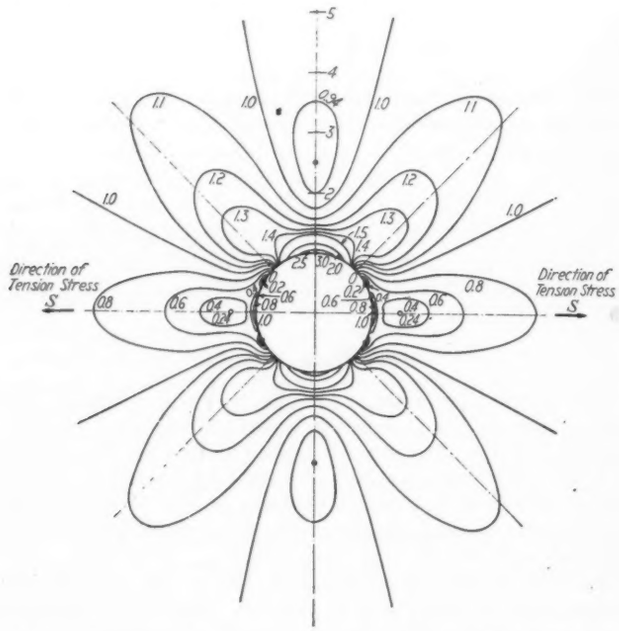


FIG. 2 LINES OF CONSTANT MAXIMUM SHEARING STRESS $(S_s)_{max.}$ NEAR HOLE IN PLATE SUBJECTED TO SIMPLE TENSION. VALUES OF $2(S_s)_{max.}/S$ ARE INDICATED

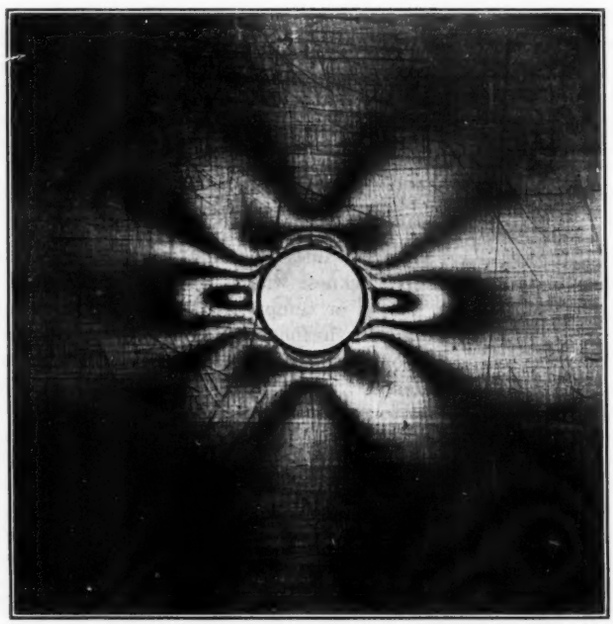


FIG. 4 BLACK-AND-WHITE PHOTOGRAPH OF COLOR BANDS AROUND HOLE IN PHOTOELASTIC TEST
(Testpiece strained uniformly in horizontal direction.)

photoelastic tests. It may be noted that the experimental results check the computed values very satisfactorily. It is therefore concluded *that the stress function F holds within the accuracy of the test for a ratio of the width of the plate to the diameter of the hole as low as 6.25.*

Since the distribution of maximum shear is not obvious from Figs. 2–4 without some study, a model was made for demonstration purposes (Fig. 6) which employs the third dimension. This model gives a topographical picture of the values of the maximum shearing stress. The scale chosen was such that 1 in. in the vertical direction represented the average stress $S = 2(S_s)_{max.}$. The light portions in Fig. 6 are those where $2(S_s)_{max.} > S$, whereas the dark parts are those where $2(S_s)_{max.} < S$.

It will be noticed that (1) *the true stress-concentration effect extends only over a comparatively small area* in the vicinity of the "peaks" in the surface representing $(S_s)_{max.}$; (2) *the contour lines for the value* $K = 1$, i.e., the lines along which the maximum shearing stress is the same as that in the undisturbed parts of the plate at infinity, *extend to infinity;* and (3) that *there are four areas of depression* (distributed along the axis of tension and the axis at 90 deg. to the axis of tension), where the material is stressed below $K = 1$.

Explanation of Yielding Phenomena in Compression or Tension Test Specimens With Holes

For ductile materials with a well-defined yield point, the criterion of failure by plastic flow can be expressed by certain functions of the second degree of the stress components or of the three principal stresses. For the sake of simplicity, it is sometimes advisable to replace these more general conditions of failure by a special condition. For ductile materials like low-carbon steel or a cold-worked hard copper (not annealed) the maximum shearing stress may, within a few per cent of exactitude, be considered as the quantity on which yielding depends. On this basis we may assume that failure by yielding will take place first at points where the greatest absolute shear stress occurs, that is, where the ultimate shear $(S_s)_{ult.}$ is a maximum, and yielding will develop at a constant value of this stress. By ultimate shear at any point is meant the greatest absolute value of shearing stress, the *third* principal stress being also considered.

Now this third principal stress can be zero, as in the case represented by Equations [2], [3], and [4], when the thickness of the plate is small compared with its other dimensions. For such a plate $(S_s)_{max.}$ as given by Equation [4] will be the ultimate shear only for those points where the principal stresses S_1 and S_2 are of opposite sign. For all other points, where the principal stresses are of the same sign (both tension or both compression), the ultimate shear will be equal to one-half the larger principal stress.

Calculation of Lines of Constant Ultimate Shear. It is therefore of interest to calculate the lines of constant ultimate shear for this case. As mentioned before, the ultimate shear is equal to:

$$(S_s)_{ult.} = \frac{S_1}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots [7]$$

where both principal stresses have the same sign, S_1 being the greater principal stress. But from Mohr's circle the principal stresses are:

$$\left.\begin{aligned} S_1 &= \frac{S_r + S_t}{2} + (S_s)_{max.} \\ S_2 &= \frac{S_r + S_t}{2} - (S_s)_{max.} \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots [8]$$

Where $|S_{s\ max.}| < |(S_r + S_t)/2|$, it is clear that the principal stresses will have the same sign. Hence in these cases the ultimate shear $(S_s)_{ult.}$ will be given by Equation [7]. On the other hand, where $|S_{s_{max.}}| > |(S_r + S_t)/2|$, the principal stresses will be different in sign and the ultimate shear will be equal to $(S_s)_{max.}$ as given in Equation [4]. The contour lines of the function $2(S_s)_{ult.}/S$ are shown in Fig. 7. This figure differs but little from Fig. 2 except at angles (α) greater than 50 deg. from the axis of tension. For instance, along the axis of tension the deviation is within

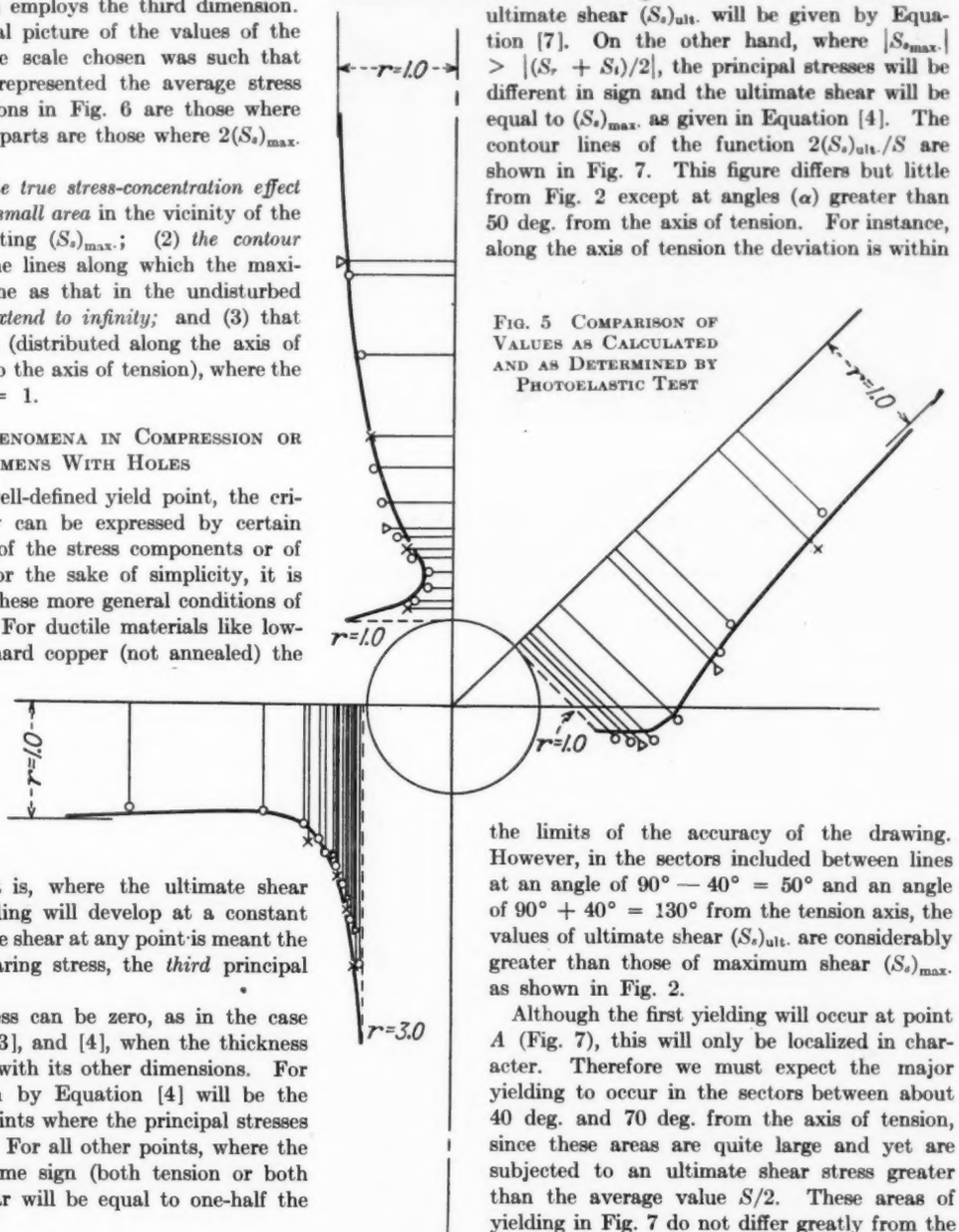


FIG. 5 COMPARISON OF VALUES AS CALCULATED AND AS DETERMINED BY PHOTOELASTIC TEST

the limits of the accuracy of the drawing. However, in the sectors included between lines at an angle of $90° - 40° = 50°$ and an angle of $90° + 40° = 130°$ from the tension axis, the values of ultimate shear $(S_s)_{ult.}$ are considerably greater than those of maximum shear $(S_s)_{max.}$ as shown in Fig. 2.

Although the first yielding will occur at point *A* (Fig. 7), this will only be localized in character. Therefore we must expect the major yielding to occur in the sectors between about 40 deg. and 70 deg. from the axis of tension, since these areas are quite large and yet are subjected to an ultimate shear stress greater than the average value $S/2$. These areas of yielding in Fig. 7 do not differ greatly from the light areas of Fig. 6.

In Fig. 7, a dotted line *AB* marked "line of maximum ultimate shear" has been drawn. This line, which is inclined at an angle of about 50 deg. to the tension axis for most of its length, is the locus of the points where $\frac{\partial(S_s)_{ult.}}{\partial\phi} = 0$, or where the maximum ultimate shear $(S_s)_{ult.}$ is the largest as one proceeds radially outward from the hole. It would be reasonable to expect that, as the load is increased, progressive yielding will follow this line.

On this basis, therefore, one should reason that yielding would

progress at an angle of about 50 deg. But against this reasoning it should be considered that (1) no account is taken of the disturbance produced by progressive change in the form of the

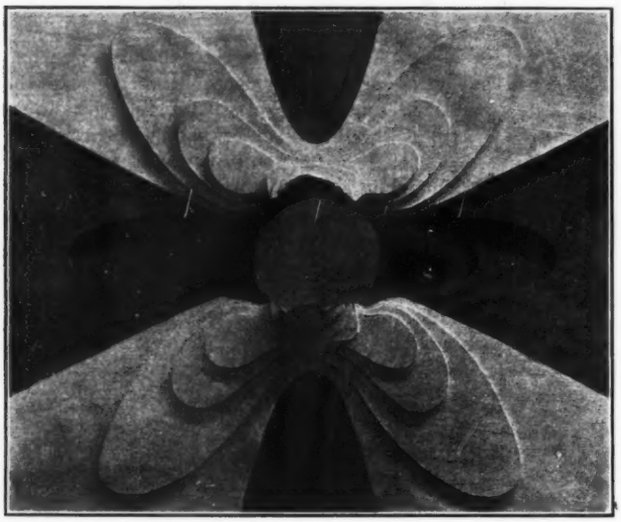


FIG. 6 PHOTOGRAPH OF MODEL FOR ILLUSTRATING STRESS DISTRIBUTION

contour lines of constant ultimate shear. The form of these lines was calculated on the assumption of pure elastic deformation. Their shape will, of course, be changed when the yielding of the plate has covered a considerable area in the vicinity of the hole; and (2) that it would make no difference whether the

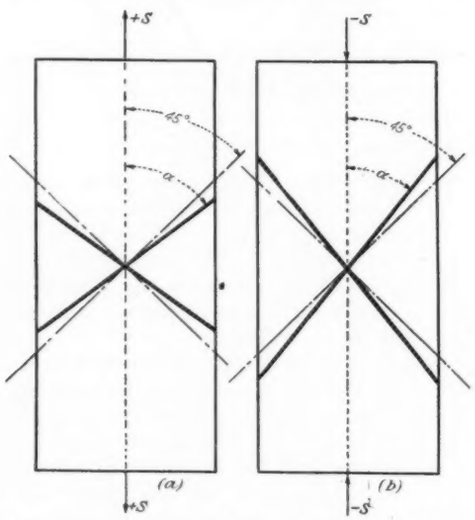


FIG. 8 LOCATION OF GLIDING SURFACES IN TENSION AND COMPRESSION

plate was subjected to a tensile or a compressive stress. Now from many tests with plastic materials it is well known that the angle α (Fig. 8) between the slip or gliding surfaces and the direction of tension (or compression) is greater than 45 deg. for tension, and less than 45 deg. for compression.

We must conclude, therefore, that a complete discussion of the progression of yielding should include some new point of view, by which the slipping phenomenon or the actual position of the slip surfaces with respect to the directions of principal stresses (the magnitude of the angle α) is correlated with the mechanical properties of the plastic material.

In this paper, however, it is not possible to go into more detail regarding this, but it should be noted that for certain ductile materials, tests seem to indicate that the angle α does

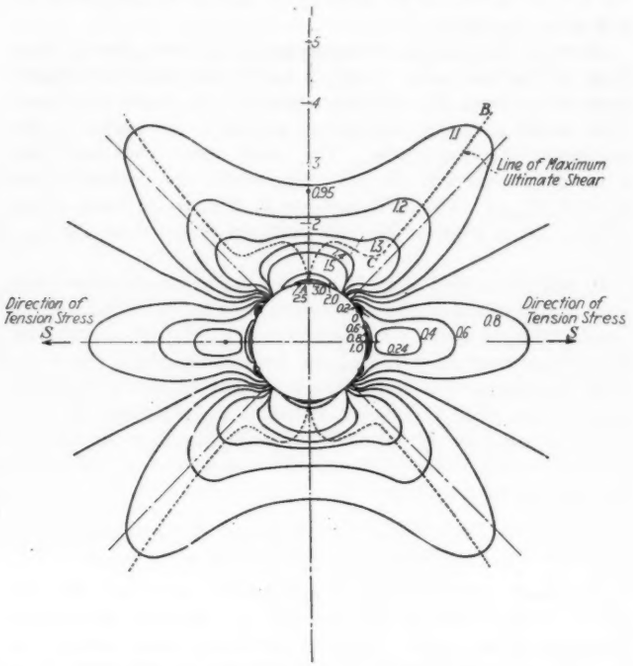


FIG. 7 LINES OF CONSTANT ULTIMATE SHEARING STRESS $(S_s)_{ult.}$ IN PLATE WITH CIRCULAR HOLE AND SUBJECTED TO SIMPLE TENSION. VALUES OF $2(S_s)_{ult.}/S$ ARE INDICATED

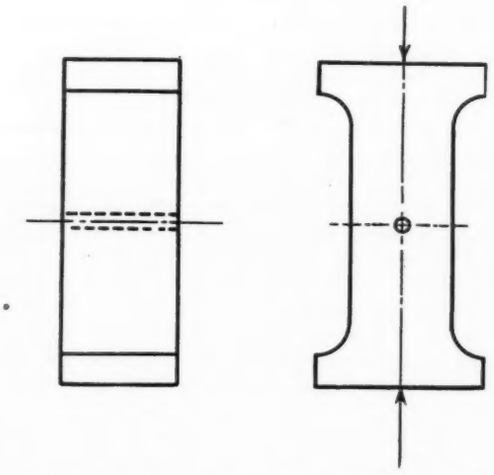


FIG. 9 FORM OF COPPER TEST PIECE WITH HOLE

not differ much from 45 deg. Such materials are, for example, low-carbon steel and copper under certain conditions.

TESTS WITH HARD-COPPER AND ANNEALED-STEEL COMPRESSION-TEST SPECIMENS WITH HOLES (FIG. 9)

Figs. 10–18 are reproductions of photographs[6] which show the development of the plastic layers as they progress from the hole under increasing stress, the test pieces being subjected to compression. The test pieces of Figs. 14–18, of low-carbon steel, were machined at first, then annealed at about 930 deg. cent. for

[6] In taking these photographs the Töpler "Schlieren" method was used as described in *Schweizerische Bauzeitung*, vol. 83, no. 14, p. 157.

one hour and polished on one side. The test pieces of copper (Figs. 10–13) were machined from a block of copper which had first been compressed about 33 per cent. This initial deformation had the effect of cold working the copper, thus bringing it into a condition mechanically similar to the annealed-steel piece, i.e., both metals show a well-defined yield point. Both test specimens *a* and *b* (Figs. 14–18) were cut from the same

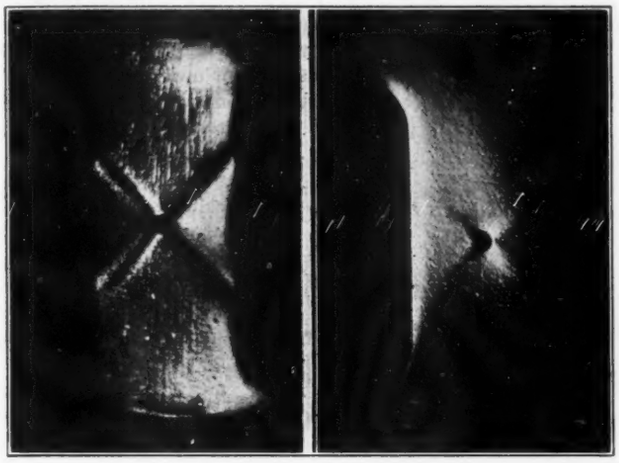


FIG. 10 (*Left*) COMPRESSION TEST OF HARD-COPPER SPECIMEN (*a*) HAVING HOLE

(Two very well-defined layers of plastically deformed copper may be seen; these cross in the axis of the hole.)

FIG. 11 (*Right*) COMPRESSION TEST OF HARD-COPPER SPECIMEN (*b*) HAVING HOLE

(*S* = 36,400 lb. per sq. in. Cross-section of specimen = 0.42 sq. in.; diameter of hole = 0.047 in.)

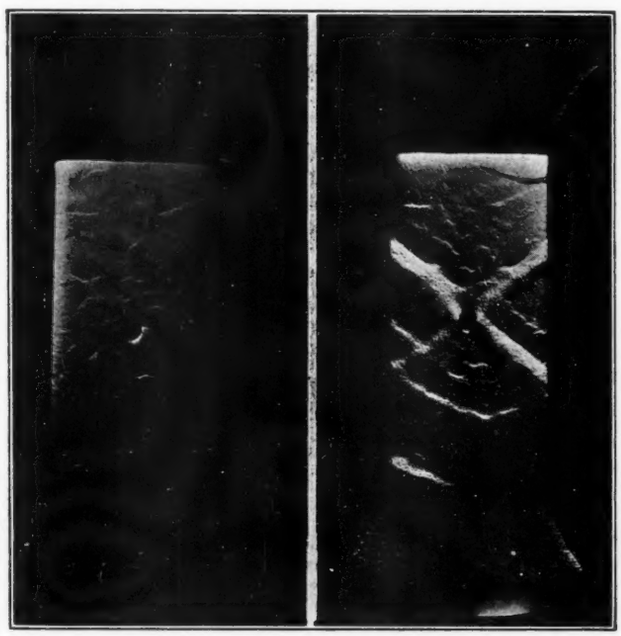
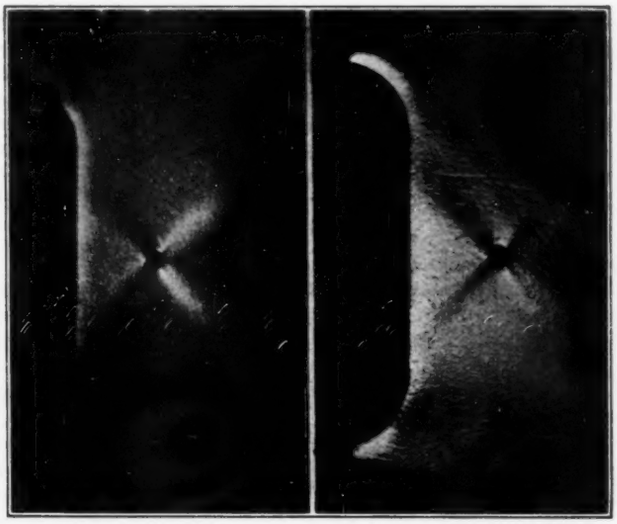


FIG. 14 (*Left*) COMPRESSION TEST OF MILD-STEEL SPECIMEN (*a*) HAVING HOLE

(*S* = 34,200 lb. per sq. in. Cross-section of specimen = 0.325 sq. in.; diameter of hole = 0.047 in.; yield point of steel in compression = 37,000 lb. per sq. in.)

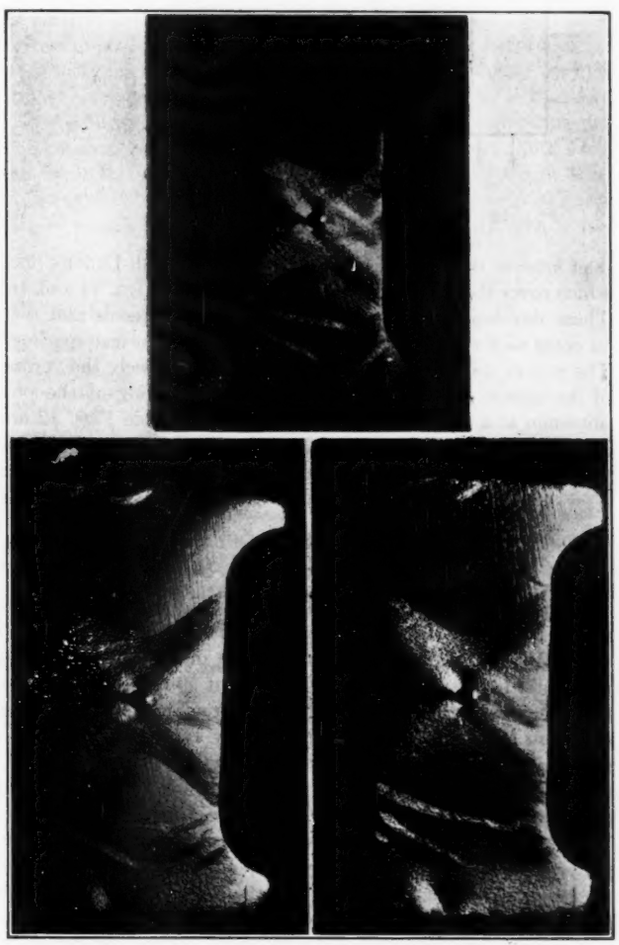
FIG. 15 (*Right*) COMPRESSION TEST OF MILD-STEEL SPECIMEN (*a*) HAVING HOLE

(*S* = 39,000 lb. per sq. in.)



FIGS. 12 AND 13 TWO PHOTOGRAPHS, WITH DIFFERENT ILLUMINATION, OF COMPRESSION TEST OF HARD-COPPER SPECIMEN (*b*) HAVING HOLE

(*S* = 42,700 lb. per sq. in. Cross-section of specimen = 0.42 sq. in.; diameter of hole = 0.047 in.)



FIGS. 16–18 THREE PHOTOGRAPHS, WITH DIFFERENT ILLUMINATION, OF COMPRESSION TEST OF MILD-STEEL SPECIMEN (*b*) HAVING HOLE

(*S* = 38,100 lb. per sq. in. Cross-section = 0.354 sq. in.; diameter of hole = 0.047 in.; yield point of steel in compression = 37,000 lb. per sq. in.)

steel bar. The yield point of the steel was found by an ordinary compression test to be S = 37,000 lb. per sq. in. When the specimen a having the hole (Fig. 14) was subjected to an average compression stress of S = 34,200 lb. per sq. in., the first changes in the reflection of the polished surface could be seen in the vicinity of the hole. After the load was increased from 34,200 to 39,300 lb., the "cross," indicating the plastic layers, appeared suddenly on the polished side of the steel piece (Fig. 15). It is of interest to note the small irregularities (small Lüder's lines) which cover the polished face of the specimen a (Figs. 14 and 15). These developed under comparatively small stresses and seem to come as a result of "inelastic buckling" of the test specimen. The copper specimens (Figs. 10–13) show very nicely the "cross" of the plastic layers. Fig. 11 shows the beginning of the phenomenon at a stress of 36,400 lb. per sq. in., while Figs. 12 and 13 were taken (with different illumination) using the same test piece after the test piece was subjected to a compressive stress S = 42,700 lb. per sq. in.

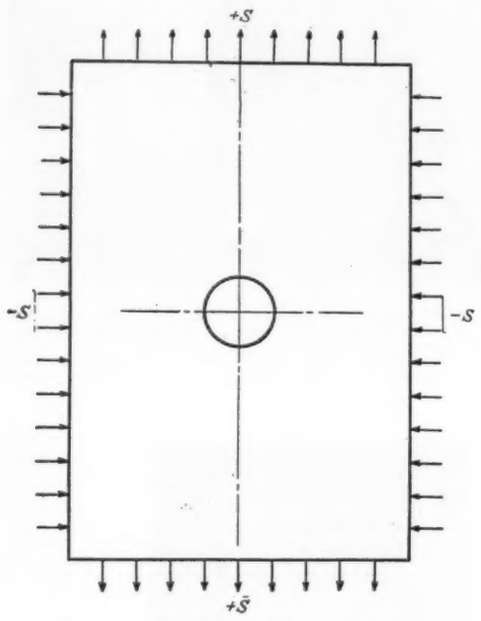


FIG. 19 PLATE WITH HOLE IN SHEAR

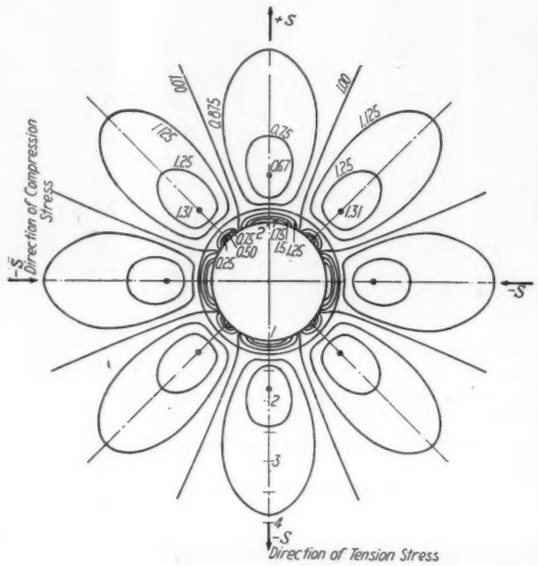


FIG. 20 LINES OF CONSTANT MAXIMUM SHEARING STRESS $(S_s)_{max.}$ NEAR HOLE IN PLATE SUBJECTED TO PURE SHEAR. VALUES OF $2(S_s)_{max.}/S$ ARE INDICATED

CONCLUSIONS FOR THE CASE OF A PLATE IN TENSION OR COMPRESSION

From calculation and photoelastic tests we may conclude that within the elastic range the major part of the maximum ultimate shear (Fig. 7) is distributed over a line directed radially from the center of the hole at an angle of about 50 deg. to the axis of tension. Furthermore, from the Lüder's-lines tests on steel and hard copper in compression, we may conclude that the beginning of plastic flow in such cases occurs in two comparatively thin layers which cross in the axis of the hole and progress at about 45 deg. to the direction of the compression.

As soon as yielding in a point such as C (Fig. 7) starts in materials with a well-defined yield point, a small *increment of the load spreads the failure over large portions* since the slope of the surface of ultimate shear here is so small. This fact seems to have some importance for the designer. It may be necessary for him to consider to what distance from the hole yielding is permissible. For example, if absolutely no yielding of the tension or compression member is allowable, then a factor of safety of 3.0, with respect to yield point, should be chosen, to take into account the stress concentration 3.0 in point A: S = Y.P./3.0. However, under static conditions with ductile material, some yielding, as, for instance, far as the contour line 1.4, will probably be permissible without serious danger of failure of the construction. In such case a factor of safety, with respect to yield point, of about 1.4 could be used: or S = Y.P./1.4. In other cases the designer must use his own judgment.

The practice, which has lately come into use in the construction of high-speed rotating machines, of overstraining certain machine elements to produce residual stresses of opposite sign before putting these elements into actual service, may possibly allow a reduction in the factor of safety mentioned above. In doing so, the designer may find the calculated curves of ultimate shear (Fig. 7) useful, since they tell him approximately how the overload will affect a tension or compression member with a hole.

It should be noted that the data obtained in the tests apply only in the case of a ratio of width of plate to diameter of hole of $6^1/_4$ or larger. This follows since the stresses obtained by the use of the stress function agree with those obtained experimentally within the accuracy of the photoelastic tests. For ratios less than this, specific photoelastic tests may be made.

ACKNOWLEDGMENT

The authors wish to acknowledge their indebtedness to S. M. Kintner, director of the Research Laboratories of the Westinghouse Electric and Manufacturing Company, and to J. M. Lessells, in charge of the Mechanics Section, for the use of facilities in making this investigation.

Appendix No. 1

IT IS of interest to determine the distribution of the lines of constant maximum shear in a plate with a hole, the plate being subjected to pure shear, i.e., a uniform tension combined with an equal compression acting at right angles (see Fig. 19). In such a case, the distribution of the lines of constant maximum shear have the form shown in Fig. 20. These may be obtained by the application of general equations of the theory of elasticity or by superimposing the stresses represented by Fig. 2 upon another set of stresses similar to those represented by Fig. 2, but displaced through an angle of 90 deg. The superimposed stresses are to be taken as negative; the result is the series of contour lines shown in Fig. 20. These represent the locus of points having constant values of $K = 2(S_s)_{max.}/S$ as before.

Because of the difficulty of loading a model to fulfil the conditions of pure shear, no tests have been made as yet to check up the distribution of stress shown in Fig. 20. It is perhaps worth mentioning here that such a stress distribution around a hole might be obtained in the *web of an I-beam subjected to a severe transverse shearing load.* The central part of the web can then be considered as stressed in pure shear, and if the amount of shear is large enough, the material should yield in the vicinity of a hole in the web along two perpendicular planes, according to Fig. 20.

Building Vessels for High-Pressure and High-Temperature Service

By T. McLEAN JASPER,[1] MILWAUKEE, WIS.

This paper discusses the research work on vessels that has been carried to the point of practical application by pointing the way to correct design and fabrication in the production of containers for high-pressure and high-temperature service.

It indicates the methods which have been used to evaluate designs of vessels, and the means which have been employed to determine the correct strength of steels at elevated temperatures representative of service conditions.

It also demonstrates the possibility of joining steel plates with a ductile weld which is stronger than the plates joined, thereby eliminating the necessity of increasing the thickness of vessels at the joints. It shows the remarkable ductility and impact value of this deposited weld metal, and further shows that the act of welding does not decrease the strength of the joint immediately adjacent to the weld.

It reveals that studies on steels have shown the way to obtain homogeneous metal with the present methods of producing steel, by cropping 50 per cent of the ingot.

The value of elliptical heads as compared with dished heads is shown, also the necessity and value of correct reinforcement of openings. These results were not obtained on miniature test vessels but on commercial-size vessels, 40 ft. long, 6 ft. in diameter, and 2 in. in wall thickness.

The process described is now over eleven years old and is the result of considerable thought and directed energy.

Many of the vessels built have been in continuous operation for over four years in the most hazardous of any service—the oil-cracking industry.

IN THE building of vessels for high pressure and high temperature it is becoming increasingly necessary to carefully reconsider the questions of design and construction from the point of safety because of two very important reasons.

First, because the engineers for the steam-power, oil-refining, and chemical industries desire to make use of the economies rendered possible by going to higher and still higher temperatures and pressures. Second, because the problems associated with the safety of equipment under those increasingly severe service conditions are becoming more and more difficult as the temperatures and pressures are increased.

The theory underlying the principles outlined on the following pages has been fairly well understood for some time. However, the practical application of these principles was not possible so long as there was no known method of fabrication by which the advantages could be capitalized. For example, there was no point in redesigning heads or reinforcing openings in an attempt to strengthen these parts, so long as the joints in the vessel remained the weakest link.

The vessel with a riveted joint has little safety beyond the yielding stress of the metal, because at this point the distortion of joints results in leaks and therefore renders the vessel unreliable. For this reason unreinforced openings and the ordinary dished heads, although weak in design, are justified in combination with riveted construction.

It might be thought that there is no need of considering stressing vessels above the yielding point. This, however, is not true, for in the oil-cracking industry, as an example, experience has proved that the pressure may, in spite of safety devices, momentarily go considerably beyond the normal working pressure, and may even run the stress above the yield point. In the United States, accident analysis has shown that this has been the cause of failure in at least three serious cases, all within the last three years. The heavy toll of human lives and great financial loss to equipment class them as major disasters.

It therefore becomes increasingly important that the vessels for use in such services, which are growing more hazardous because of the demands of economics, should be produced with the utmost care and all precautions taken to insure safety to the users.

It should be understood that vessels for high-temperature and high-pressure operation require the use of relatively thick walls, and that thick-walled vessels act very differently from thin-walled ones. The reason is that very little adjustment of shape under pressure can take place even when relatively ductile materials are employed.

The four most important points in considering vessels for severe service are as follows:

1 Design
2 Materials
3 Fabrication
4 Testing.

Design

The design of a thick-walled vessel in which the plate ranges from $1^1/_2$ to 6 in. in thickness is of great importance, because if improperly or carelessly designed it may have less than one-half the strength that the materials used could produce. The proper design of a vessel considers as the most important items the shape of heads, proper reinforcing, and the efficiency of the joints produced in fabrication.

The only satisfactory way by which the correct answer can be found as to what constitutes a proper design, is to build vessels of full size and test them to the yield point of the steel, and eventually to destruction.

The principle underlying such tests takes into consideration that the various points in a vessel under pressure will show yield at different pressures, depending upon when the metal at these points reaches its yield point. It is obvious that yielding will first take place at the weakest point. Therefore, if the design is not a well-balanced one, then the pressure at which the first yielding occurs compared to the pressure at which the main cylinder yields, will give a very good idea of how well balanced the design really is.

In the tests described below, the actual measurements were obtained by using Berry strain gages of 2-in. and 4-in. gage lengths

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[1] Director of Research, A. O. Smith Corporation. Mem. A.S.M.E.

Abstract of paper read before the World Engineering Congress, Tokyo, Japan, October 20–25, 1929. Slightly revised and rearranged, and with additional illustrations.

applied to a series of about 200 gage points scattered over each of the vessels.

The vessel used for one of the tests was approximately 40 ft. long, 72 in. in inside diameter, and had a 2-in. wall thickness (see Fig. 1).

To one end of the vessel was welded an elliptical head having the shape of one-half of an ellipsoid of revolution. The major axis of the ellipse is two times the minor axis, the major axis being equal to the diameter of the vessel.

On the other end of the vessel was a dished head with a shape composed of two curves having radii of 72 in. and 10 in., respectively. The part of this head, where maximum strain occurred was where these two curves became tangent. This is also shown in Fig. 2 where the limewash first came off during the test.

In the side of one of the vessels were three 24-in. manway openings, two of which were reinforced and one unreinforced. The degree of reinforcement necessary was previously determined from other vessels by increasing the width of the reinforcing ring until no yielding at any point adjacent to the openings occurred before the stress there was as high as in the main cylinder. For the type of construction employed, which will be described later, the correct reinforcement was found to be a ring whose thickness was equal to that of the vessel wall and of a width equal to 40 per cent of the opening.

These reinforcements are attached to the vessel by drilling through the rings and, after placing them in position, fusing weld material into the holes. Thus the two are bound together as one piece at a number of spots. Finally welding is applied around the outside edge as well as adjacent to the manway neck, insuring that the reinforcing rings are attached firmly to the vessel proper. This method of reinforcing was also found adequate for openings which were placed in heads.

Fig. 2 Dished Head Showing Scaling of the Limewash During Test, Indicating Where Maximum Stress Occurred

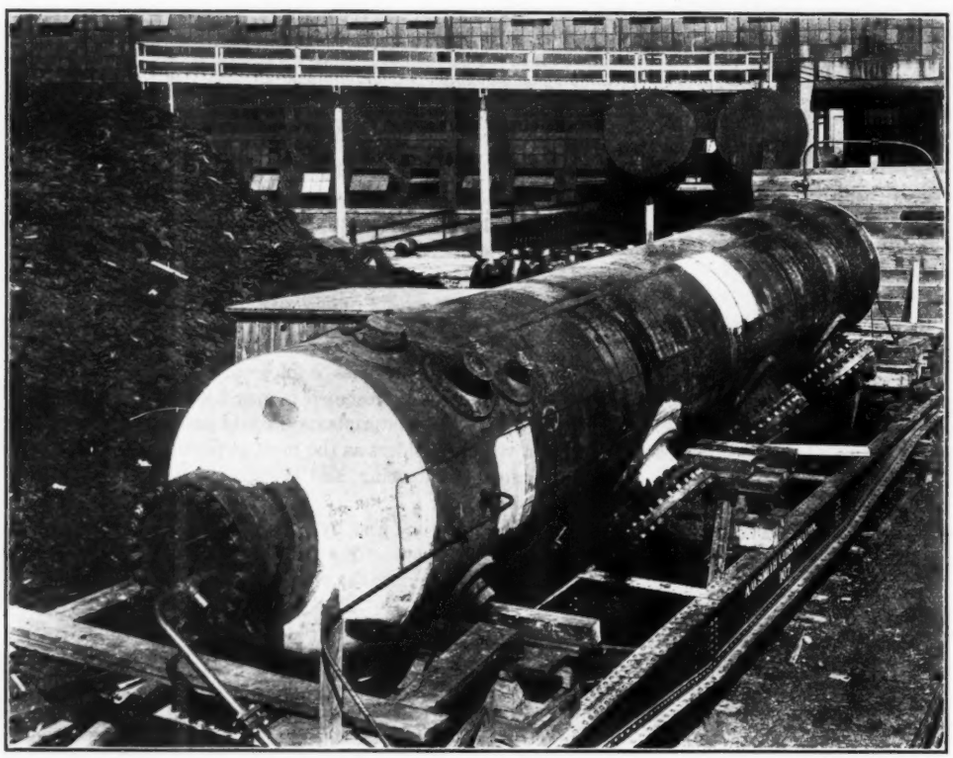

Fig. 1 Vessel Used in One of the Tests. Note the Application of Limewash Over Areas to Be Studied

(Length, 40 ft.; inside diameter, 72 in.; wall thickness, 2 in.)

Fig. 3 presents the test results, which indicate the yield points of the two main weak spots that most commonly show up due to improper design, and also the point of yield in the main cylinder. When the yield point in the main cylinder was checked against the value obtained on the actual plate, before any fabrication was done, it was found that the two results were exceedingly close.

The following common stress formula was used for checking the cylinder strength:

$$S = \frac{PD}{2t}$$

in which

S = stress in the material
P = test pressure
D = diameter of the pressure container, and
t = thickness of the wall.

From a study of Fig. 3 it is seen that an unreinforced 20-in. manway in a vessel of 2 in. wall thickness and 72 in. in diameter, has a strength of about 60 per cent of that of the cylinder wall. Further, it is seen that a dished head as described above has a strength of about 80 per cent of the cylinder wall.

Fig. 4 indicates results of similar tests, when the manway openings are adequately reinforced and when a head of elliptical design is used.

Fig. 5 shows the vessel after it had failed beyond repair. The first failure resulted from faulty design, and occurred as expected at the reinforced manway opening. It cracked around the connection between manway and shell. This was repaired and the opening reinforced as described above. The final failure occurred in the short radius of the dished head, and progressed along the full length of the vessel proper as shown. The first failure (at manway) occurred at about 64 per cent of the strength of the steel in the main cylinder, and the final failure (in dished head) occurred at about 82.5 per cent of this strength. This gives a fairly close check of the yield-point results obtained in the test, which used the yielding of the material to indicate the quality of the design.

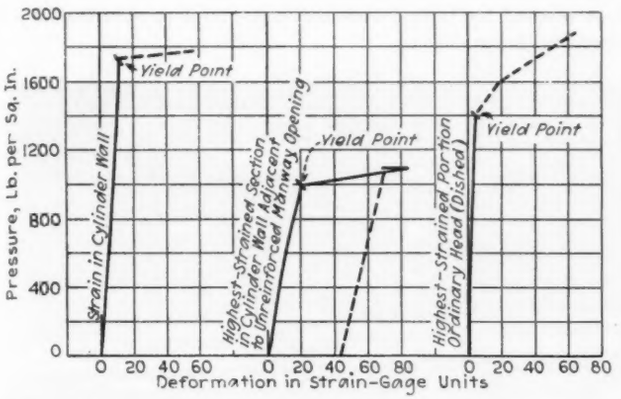

FIG. 3 CURVES SHOWING LACK OF UNIFORMITY IN THE STRENGTH OF A VESSEL WHEN DISHED HEADS AND UNREINFORCED OPENINGS ARE USED

(These test results were obtained simultaneously during one pressure test. Length of vessel, 40 ft.; inside diameter, 6 ft.; wall thickness, 2 in.; the stress in the metal was the same at each test point when the yield point was reached.)

A typical failure due to unreinforced openings is shown in Fig. 6. This test vessel had the same dimensions as the one shown in Fig. 7, but failed at about 40 per cent lower pressure.

It must be understood here that walls of thin material, say, $^1/_2$ in. or so, would not likely have shown such close results between the point of yield and that of failure, because such vessels are freer to adjust themselves to shape under pressure.

One other point should be noted in Fig. 5. This vessel was of welded construction in which the weld section was practically the same thickness as the plates joined. Vessels of this make are now designed to give uniform strength throughout; that is, they are made as strong in every part as in any part. Localized stiffening of the joints is practically eliminated, and the vessel is free from uncertain stress distribution and concentration. The importance of this cannot be overemphasized in the selection of vessels for severe service conditions.

The question of strength of weld will be taken up under the heading of construction, but it is desired to point out here one significant thing in this connection. In riveted construction the joints are either made by overlapping the plates or by using butt straps. In either case the metal of the joint is stressed in excess of what it is at points far removed from the joints. As the wall thickness is increased, this unbalanced stress condition becomes more important as a factor of lowering the effectiveness of the joint.

In the case of riveted construction one other thing should be kept in mind. At the yield point of the metal, which is approximately one-half the ultimate strength, the vessel will tend to leak. Such leaking represents failure in the technical sense of the word. Dished heads, therefore, are adequate under such conditions, because the leak point of the riveted joint is lower than the strength of the dished head.

In Fig. 5 it should finally be noted that the fracture avoided the neighborhood of the welds used in the construction of the test vessel. It might be added here that the vessels in question had not been built especially for testing purposes, but were regular production vessels built on order and intended for operation in service.

MATERIALS

Materials of construction play an important part in the value of a piece of equipment. The strength of such materials, considering the conditions of operation, must be thoroughly understood in order that full advantage may be taken of the various materials available. The type of pressure vessel with which the author has been most familiar, calls for continuous operation at 900 deg. fahr. and at various pressures. Certain vessels are designed for as high as 1400 lb. per sq. in. pressure. Of course, the question of pressure is simply a matter of increased wall thickness.

The vessel types referred to are being used in the oil-cracking and chemical industries where leakage would have serious consequences, such as explosion or fire. Such a fire, when impinging on an adjacent vessel, has been known to produce disasters resulting in the loss of a considerable number of lives.

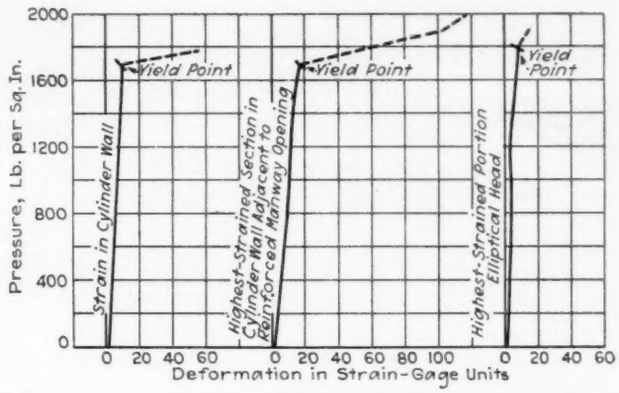

FIG. 4 CURVES SHOWING UNIFORM STRENGTH IN A VESSEL WHEN ELLIPTICAL HEADS AND REINFORCED OPENINGS ARE USED

(Length of vessel, 40 ft.; inside diameter, 6 ft.; wall thickness, 2 in.)

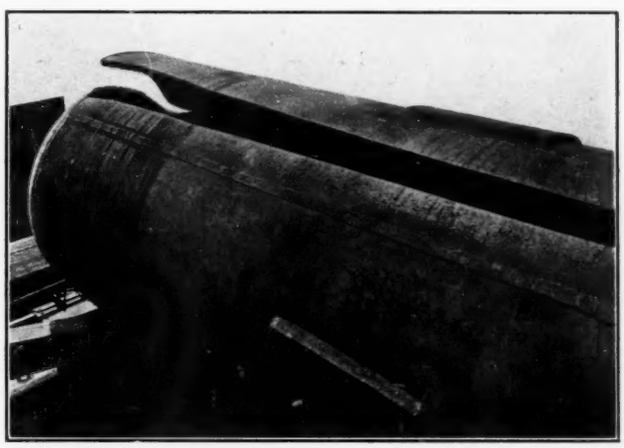

FIG. 5 VESSEL AFTER CONCLUSION OF DESTRUCTION TEST

The strength of steel at elevated temperatures is of great importance in connection with vessels for high-temperature service. This strength value of steel cannot be obtained in as simple a manner as is done for low temperatures. That the short-time test results do not produce correct values to be used in design, is shown in the next column by the difference between short-time and long-time values at 900 deg. fahr. for two plain carbon steels.

Two things are obvious from these data. First, the 0.10 per cent carbon steel at 900 deg. fahr. is not so strong as the 0.25 per cent carbon steel at the same temperature. Second, when the factor of safety is based on the short-time test, such a vessel will, in actual service at 900 deg. fahr., be operating at only one-half of the expected factor of safety.

Type of steel	Ultimate strength at 900 deg. fahr., lb. per sq. in. Short-time	Long-time
SAE 1010 (*a*)	32,500	15,000
SAE 1025 (*a*)	34,300	18,000

(*a*) Society of Automotive Engineers' specifications.

The men who first recognized the effect of temperature on metals were LeChatelier,[2] Chevenard,[3] and Lea,[4] and it is considered that they are parents of the thought that steel at high temperatures and under long-time continuous load will fail at a much lower load than that shown by a short-time test.

The method of testing steel at elevated temperatures is one which should be carefully considered. It is believed that the best method for testing steel for large-vessel construction is as described below.

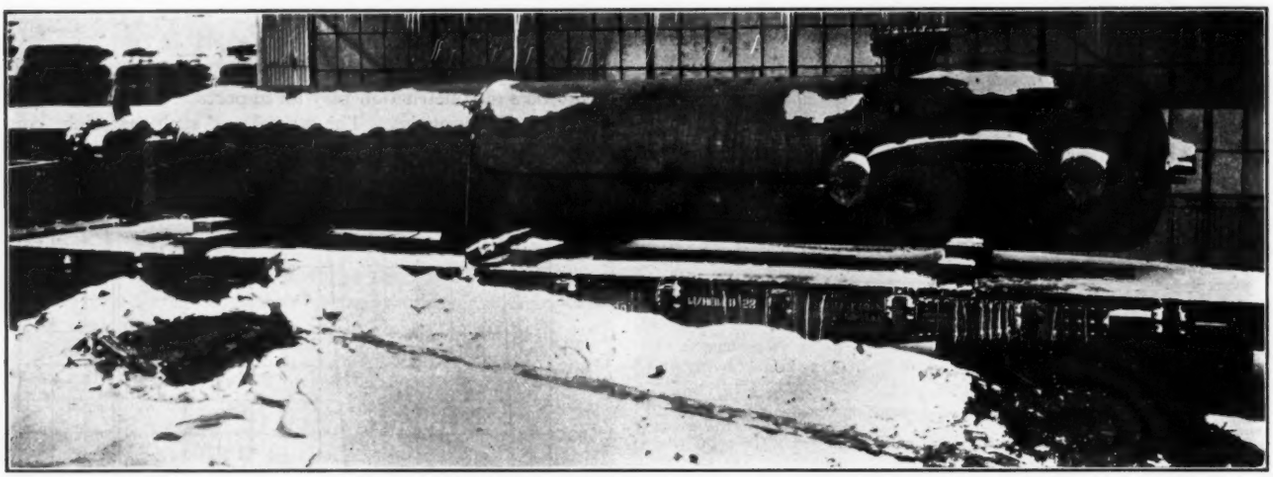

FIG. 6 TYPICAL RESULT OF DESTRUCTION TEST ON VESSEL WITH UNREINFORCED NOZZLES

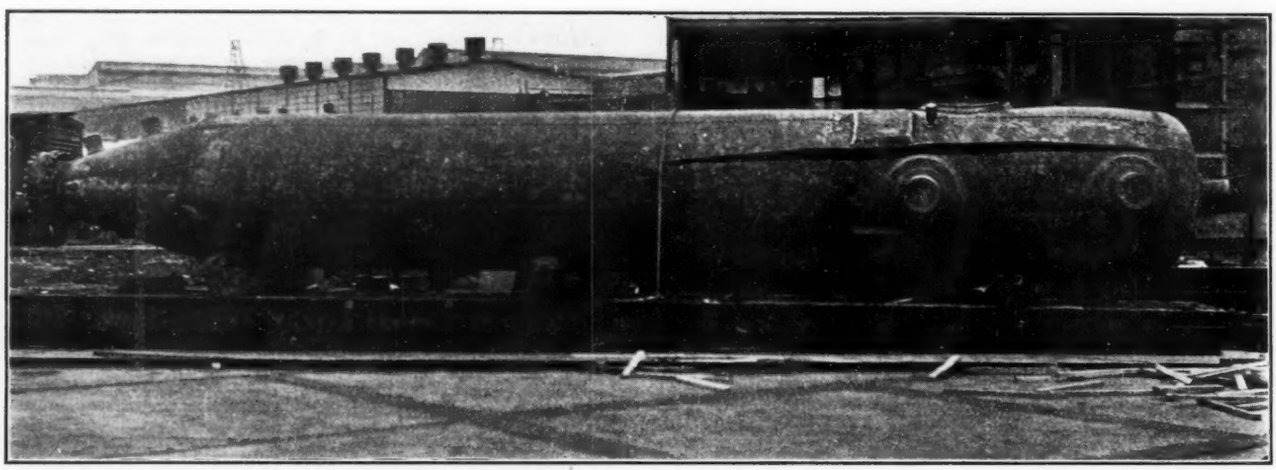

FIG. 7 BY REINFORCING ALL OPENINGS ON THIS VESSEL, THE FULL STRENGTH OF THE CYLINDER WAS REACHED AT THE DESTRUCTION TEST

The testing machine used for elevated-temperature tests is shown in Fig. 8. The operating parts consist of a system of levers attached to the test specimen by means of pulling grips. The specimen is held in a bath of lead, which is liquid when the temperature under consideration is above its melting point. This results in producing a fairly uniform temperature over the complete length of the specimen, and also allows the temperature measurement on the test specimen to be quite accurate. The thermocouple through the liquid is insulated.

One other desirable feature obtained by the use of this liquid is the prevention of oxidation, which in a small specimen may have a considerable bearing in long-time tests.

The thermocouple actuates an automatic heating control, and in this manner the temperatures are kept within very close limits.

[2] "Congrès International des Methodes d'Essai," vol. 2 (1900), p. 1.
[3] *Comptes Rendus*, vol. 169 (1919), p. 712.
[4] *Engineering*, vol. 110 (1920), pp. 293–298; Proc. Inst. M. E., December, 1924.

The method of producing satisfactory results calls for the use of several specimens of the steel to be tested and proceeds as follows:

The first specimen is subjected in the machine to a stress at which it is known to fail in time. The other specimens are subjected to successively lower stresses, until a stress is reached at

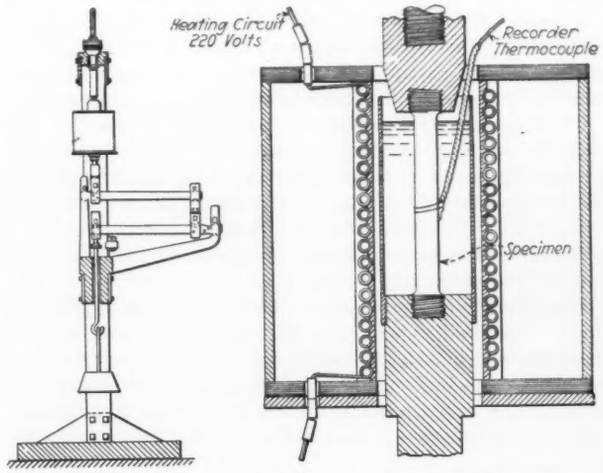

FIG. 8 SKETCH OF APPARATUS USED FOR ELEVATED-TEMPERATURE TESTS

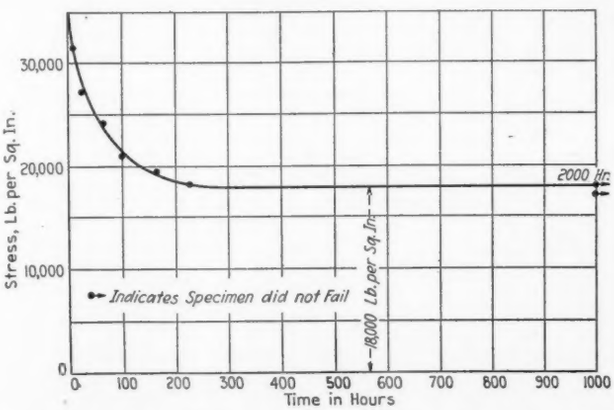

FIG. 9 CURVE SHOWING TYPICAL STRESS-TIME RELATION FOR 0.20–0.30 PER CENT CARBON STEEL WHEN TESTED AT 900 DEG. FAHR.

which it will not fail for an indefinitely long time. Fig. 9 shows a typical curve, where the horizontal line represents the long-time ultimate strength. This method of testing was first suggested by French.[5]

A fact which is not generally known is brought out in the production of thick plates. For such plates large ingots are required so as to obtain reasonable reduction in rolling. Furthermore, to make sure of homogeneous steel in the plates from the present type of ingot, it is necessary to crop 50 per cent of the metal. Thirty-five per cent is taken from the top of the plate and 15 per cent from the sides and bottom. The larger portion of the 15 per cent is taken from the bottom to avoid bottom segregation. This makes it possible to procure the homogeneous heart of the ingot for vessel construction.

It is generally conceded that a plate made by uniform forging, using the process of rolling of a once-heated steel, is superior to a steel subjected to consecutive heating and hammering. This is especially true when it becomes necessary to heat the steel several times at very high temperatures such as is required for hammer-forging operation. In this fabrication method, certain portions of the steel first forged cannot be given a final forging operation after heating.

In addition to the above observations it becomes necessary to eliminate steel having mechanical defects if a quality product is to be eventually obtained.

All materials should be purchased under strict physical and chemical specifications which, when rigidly enforced, assure required uniformity in results.

Materials of many different specifications, appropriate for producing vessels to resist various types of corrosion and high- or

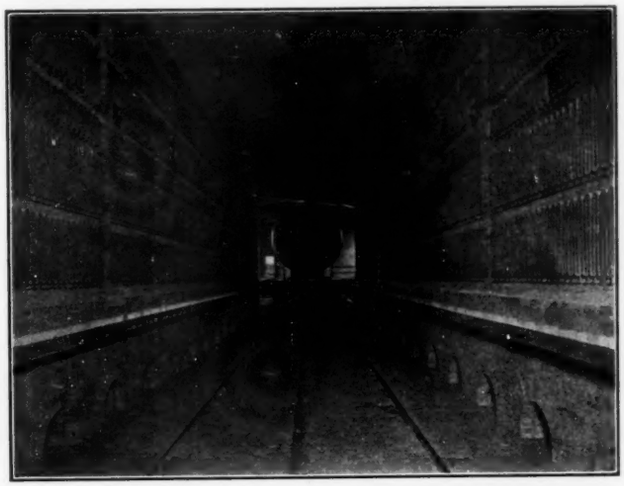

FIG. 10 INTERIOR OF ELECTRIC FURNACE IN WHICH VESSELS ARE HEATED TO RELIEVE FABRICATION STRAINS

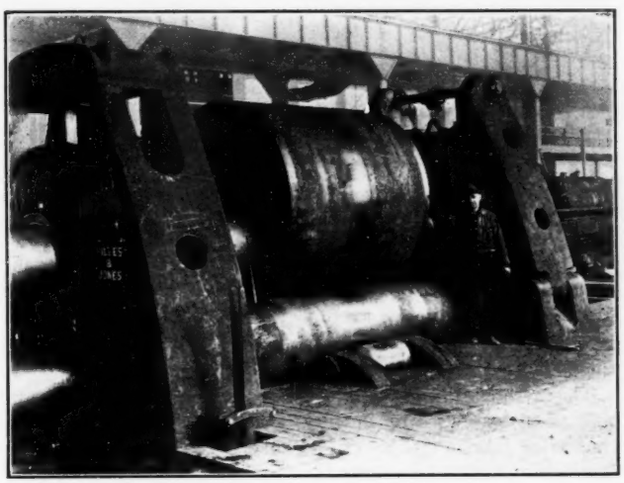

FIG. 11 BENDING ROLLS, CAPABLE OF FORMING 5-IN. STEEL PLATE COLD

low-temperature conditions, must be thoroughly investigated before vessels can be produced with a reasonable degree of certainty that safety and long life will result.

FABRICATION

The process of fabrication is one which brings the selected materials in conformity with the design. If the design is good and the materials are good but the fabrication is poor, then very little is gained. It becomes necessary, therefore, to insure that the care exercised in the process of fabrication is such as to give a

[5] Proc. Am. Soc. Test. Matls., vol. 25, part 2 (1925), p. 12.

balanced quality to the design and the selected materials.

Vessels having a wall thickness of $6^1/_2$ in. in certain sections, and weighing 396,000 lb., have been fabricated. Such vessels were 10 ft. in inside diameter and 67 ft. long. To safely transport these vessels to their destination it became necessary to survey the available routes for bridges which would carry the concentrated load and for roads where the radii of the curves were not so short that they would endanger the load.

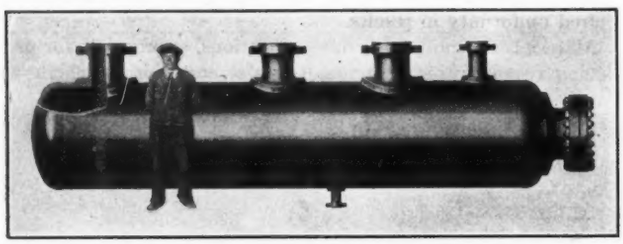

Fig. 12 Typical Thick-Walled Vessel Used in the Oil Industry

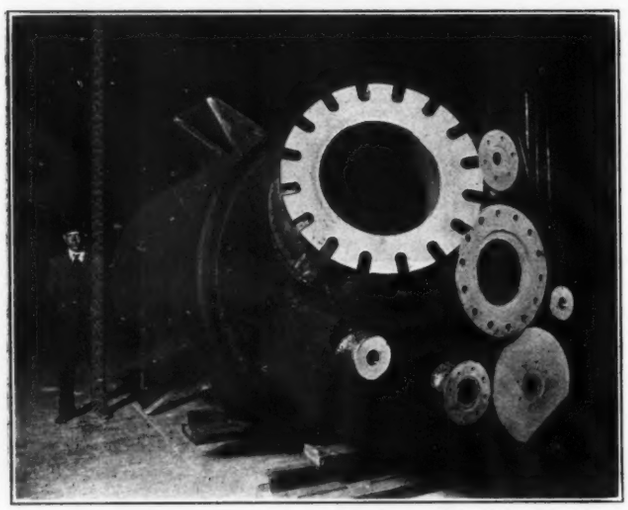

Fig. 13 Jacketed Thick-Walled Vessel Used in the Chemical Industry

The company with which the author is associated has built over one thousand vessels, weighing on an average of 120,000 lb. each and having an average wall thickness of about 2 in. In one month more vessels of this class were built and shipped by them than were produced by the rest of the world in the year.

The method of construction followed by this company requires that all plates over 1 in. in thickness shall be formed hot. Also that after fabrication the vessel shall be relieved of all major fabrication strains by proper heating. For this purpose electric heating furnaces are available. The furnace in which fabrication stresses are relieved accommodates vessels 12 ft. in diameter and 68 ft. long (see Fig. 10). The temperature is controlled automatically to within 10 deg. fahr. at any point in the furnace. Two large electric slab furnaces are used for heating plates before fabrication. These furnaces are also controlled automatically.

The large bending rolls used in forming cylinders are capable of exerting a pull-down load of 8,000,000 lb. and will form a 5-in. steel plate cold (see Fig. 11). Other rolls of lesser capacity are available for thinner materials.

The security in fabrication of thick-walled vessels depends on close conformity to shape. The roundness of large vessels is kept well within one-half of one per cent, and the straightness within $^1/_4$ in. in a 30-ft. length. Some vessels of typical design are shown in Figs. 12 and 13.

The quality of the joint also has a very material bearing on the safety of a vessel.

Fig. 14 concerns test results on specimens cut from two slabs of steel $2^5/_8$ in. thick, which had been joined together by welding. Each point in the curves represents a test value obtained from specimen of the full plate thickness, cut parallel to the direction of the weld. One test specimen is wholly in the weld, one is partly in the weld and partly in the plate, while the remainder are cut at alternately greater distances from the center of the weld.

These test results show that the weld is stronger than the plate and that the act of welding has rather strengthened the metal immediately adjacent to the weld. Obviously, such results could not be obtained if blowholes or other imperfections were present in the weld. It is significant that this method produces a weld in which the blowholes are so few that they are an entirely negligible part of the section area.

Fig. 15 shows test specimens which were made from plates 6 in. thick. The weld is located in the middle, and each successive specimen was pulled after an increased number of holes, each 0.2 in. in diameter, had been drilled through the center of the weld. There is no need to discuss further the significance of this test. It indicates without question the strength of the weld

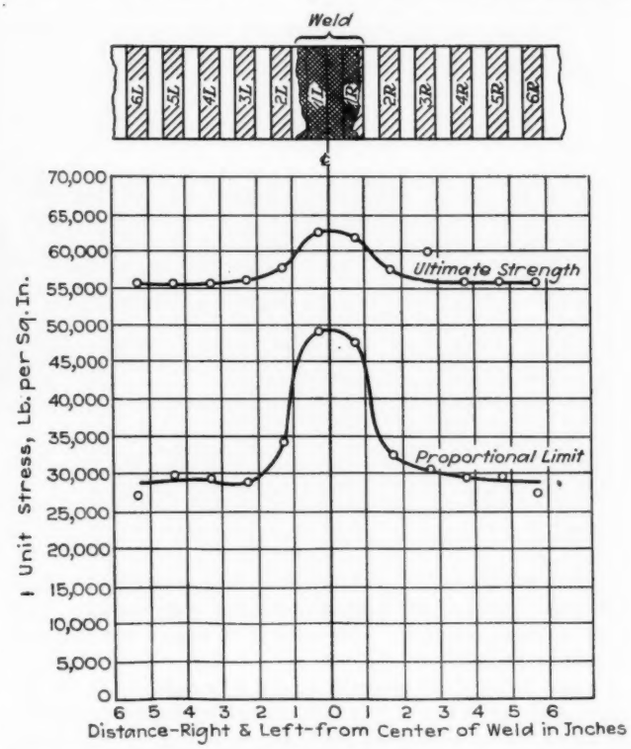

Fig. 14 Test Results on Specimens Cut at 1-In. Intervals Parallel to the Weld and Pulled in the Same Direction (Note greater strength in and adjacent to the weld.)

over that of the plate steel, and also gives some idea of the weld ductility when the shapes of the holes after failure of the test specimen are observed. It further indicates that the welding operation has had no detrimental effects on the metal immediately adjacent to it.

Incidentally this weld material has about 10 per cent higher endurance value than the plate proper. While it is considered that this quality does not enter in pressure-vessel service, it is interesting to note the ability of the weld to resist fatigue.

The remarkable ductility of the deposited weld material is brought out in numerous tests where all-weld specimens were twisted, doubled up, and even tied into bow-knots. These deformations were made with the specimens cold and without previous heat treatment of the steel after welding. Measured as elongation, a minimum value of 25 per cent in 2 in. is obtained. Such ductility is made possible by eliminating oxygen and nitrogen from the weld deposit during the process of welding, and by depositing the metal in such a manner that overheating does not occur in the plate.

Another important thing to be considered in vessel fabrication is the toughness of the joint. It is believed that the degree of toughness is indicated by the impact values of the joint metal.

Charpy tests on the weld described here consistently show from 15 to 20 per cent higher values than one obtained from the plate proper.

The method of joining steel referred to above applies to one process of arc welding, which is patented and is known in the trade as "Smithwelding." Fig. 16 shows this welding process in operation.

In conclusion, it might be said that the question of fabrication should be considered one of the most important factors influencing the quality of a vessel. Good materials, good design, and poor fabrication methods avail little, since a chain is no stronger than its weakest link. It is necessary that all three be used to their fullest possibilities if the best type of structure is to prevail.

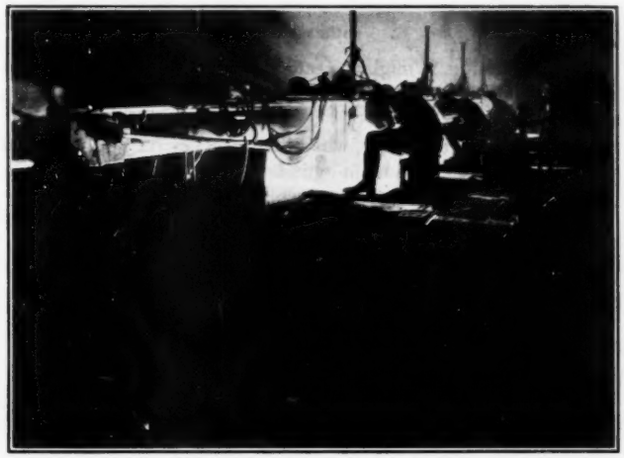

FIG. 16 SMITH AUTOMATIC ARC-WELDING PROCESS IN OPERATION

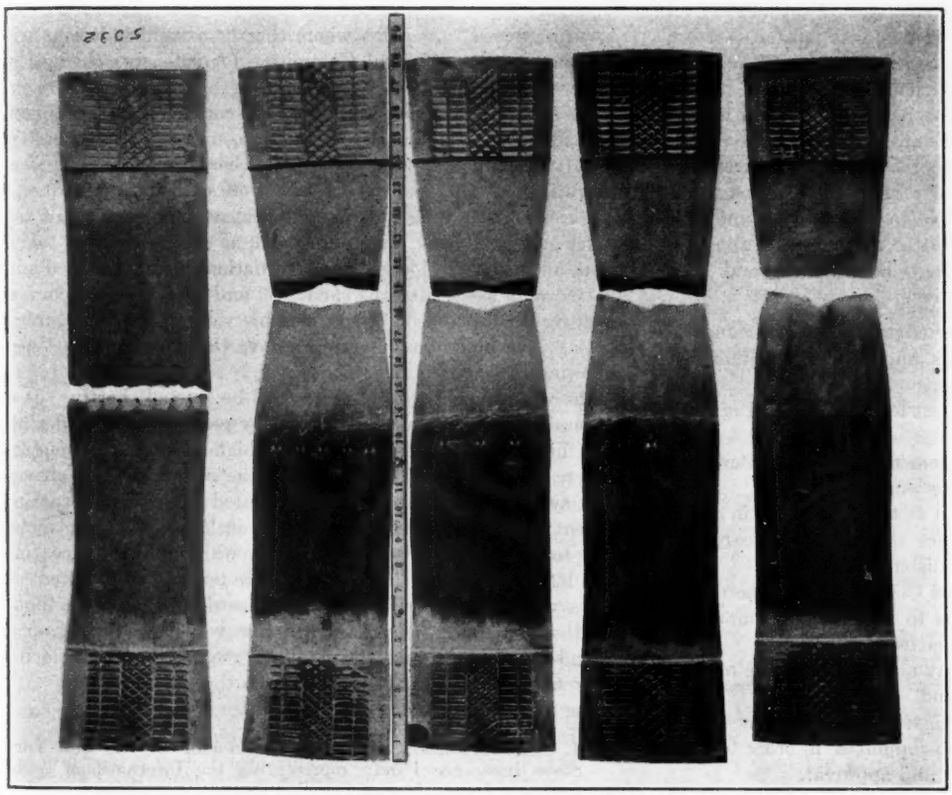

FIG. 15 TENSILE-TEST SPECIMENS CUT ACROSS THE WELD JOINING PLATES 6 IN. THICK
(Only by weakening the weld 25 per cent did the fracture occur through this section.)

TESTING

The function of testing is to determine the quality of the finished vessel. For this purpose a test pressure is selected which, for the 0.20–0.30 per cent carbon steel normally used for vessel work, produces a stress in the main cylinder of 19,000 lb. per sq. in.

In testing a vessel for use at elevated temperatures, it is obvious that no testing equipment can readily simulate operating conditions. For instance, a steam boiler would not be tested with live steam because of the amount of energy stored up in steam under such test conditions. However, if a liquid is used, which stores comparatively little energy, and the vessel is tested to a pressure proportionally higher than the working pressure, then the result will be in effect the same as if test conditions paralleled working conditions. A failure under such test conditions would not mean a disaster. Moreover considerably higher test pressures can be used without becoming a menace.

It is believed that hammering of all joints under test pressure is a most important function in vessel testing. It is also considered that with all processes of building vessels by welding and forging, this method of testing vessels should be adopted. The hammer blow in terms of energy, specified and advocated by the author's company, is an arbitrary value, which is in proportion to the weight of one square foot of metal in the vessel wall, i.e., the energy of the blow measured in foot-pounds is equal to the weight in pounds of one square foot of vessel wall.

In view of the tendency for the metal in vessels to corrode or be effected in some way or another by certain processes, it is believed that a periodical proof test could very properly be added to vessel operation. Such a proof test could be carried out by using suitable liquids, which would minimize the danger in case of

a fracture. The value of a proof test cannot be too strongly emphasized, because it will probably reduce boiler disasters to the vanishing point if properly carried out. Especially is this desirable in view of the fact that designers are going to ever-increasing temperatures and pressures.

SUMMARY

In summarizing, it might be said that the four most important points to be considered for service in which thick-walled vessels are used, are as follows:

1 A well-balanced design, which makes every part of the vessel at least as strong as the main cylinder, the strength of which can be accurately calculated. This insures a known factor of safety if the working stress is based on the cylinder stress and on the strength of the material when working conditions are considered. It also involves reinforcement of all openings and using heads of the best design.

2 A thorough knowledge of the strength of materials, with proper care taken to use only the homogeneous portion of the metal. For elevated temperatures this involves the testing of materials at the temperatures encountered in actual service and also considering the time factor appropriate to service conditions.

3 Careful fabrication methods, which insure joints of a strength equal to that of the plate without adding undue thickness. It also involves the forming of thick materials under heat, together with a final relief of fabrication strains by heat, this to insure that the vessel goes into service in a well-balanced stress condition.

4 The appropriate testing of vessels before they are put into service to assure the prospective user as to the ability of such vessels to carry the specified load. This involves a knowledge of the strength of the steel in the vessel at the test temperature and also the long-time strength of the steel at the working temperture. Appropriate periodic proof testing of vessels insures that the service deterioration of vessels is caught in time to prevent the loss of life and property. Such proof testing with care can be accomplished without involving risks commensurate with those taken when such tests are not performed. Such proof tests involve test pressures sufficiently above the working pressures so as to insure adequate safety for some appropriate period of future operation.

Research Committee on Elevator Safeties Doing Important Work

IN 1925 a "Safety Code for Elevators, Dumbwaiters, and Escalators" was prepared by a sectional committee sponsored by the Bureau of Standards, the American Institute of Architects and The American Society of Mechanical Engineers, and organized under the procedure of the American Standards Association. For the purpose of establishing a permanent committee to assist state and municipal authorities in the application of this code and to provide means for research and ultimately for approval of elevator safety equipment based on sound engineering tests, the Sectional Committee at that time appointed a Sub-Committee on Research, Recommendations and Interpretations with the following functions:

1 Carry out a study of elevator safety, including the function and operation of safeties and buffers together with their associated mechanisms
2 Decide on the methods of test for the approval of safety devices
3 Make all necessary arrangements with the Bureau of Standards to carry out this work
4 Act for the Sponsors, subject to their approval, in obtaining the funds necessary for the work of research and test for approval, and to disburse such funds
5 Recommend to the Sectional Committee such permanent changes in and additions to the Rules as may seem necessary to this subcommittee
6 Interpret the Rules when any question as to the meaning of the Rules may arise; and
7 Make such temporary application of the Rules as may seem necessary to this sub-committee in order to facilitate the procedure of test and approval.

The research work of the Sub-Committee has been financed on a prorated basis since that time by elevator and kindred manufacturers and other organizations in the amount of some $53,000 to date. The A.S.M.E. has made its facilities available for the care and disbursement of the Committee's funds.

Many communications from manufacturers, municipalities, and states have been received by the Sub-Committee asking for interpretations and recommendations. It is felt that the answering of these has gone a long way toward unifying practices. Continuous efforts have been made to simplify present rules and to modify them to meet advances in the art. This work has now progressed to a point where shortly recommendations will be made to the Sectional Committee for extensive changes in the present code.

The experimental work which has been conducted at the Bureau of Standards on buffers, is practically complete; twelve buffers have been studied and very complete records taken. Nine free-fall runs at various loads and speeds were made on each.

The records include a chronograph chart (time-travel) of the buffer and car during the stop, as well as a pressure card taken simultaneously. Velocities and retardations were computed and plotted on a sheet with the car travel and pressure-time curves. Such records have been of considerable value to manufacturers; at least five buffer manufacturers have brought out new types following these tests.

The work on under-car safeties will be started shortly. It is proposed to obtain the travel record by photographing a flexible tape hung in the hoistway with a high-speed motion-picture camera on the car. The shutter of the camera will be driven by a synchronous motor from a regulated source of alternating current; sixty pictures will be taken each second. The metal tape to be photographed will have a white pyroxylin coating with black markings. The divisions are tenths and hundredths, and a vernier guide will enable the record to be read to thousandths of a foot. The developed film will be projected on a ground-glass screen and the readings recorded. The velocity and retardations will be computed from these readings.

The membership of the Sub-Committee is:

M. H. CHRISTOPHERSON, *Chairman*, Director of Service, New York State Insurance Fund; representing the International Association of Industrial Accident Boards and Commissions
O. P. CUMMINGS, Vice-President, A. B. See Elevator Co., representing the Elevator Manufacturers Association of N. Y.
B. JONES, Consulting Engineer, Meyer, Strong & Jones, Inc., New York, N. Y., Independent Expert
D. L. LINDQUIST, Chief Engineer, Otis Elevator Co., representing the Elevator Manufactuers Association of New York.
M. G. LLOYD, Chief, Section of Safety Standards, Bureau of Standards, Washington, D. C., representing the Bureau of Standards
J. J. MATSON, Electrical Engineer, Industrial Department, General Electric Co., Schenectady, N. Y., representing the Society of Terminal Engineers

(Continued on page 248)

Modern Trends in the Design and Application of Electric Motors

Substitution of Fabricated Steel for Castings—Reduced Maintenance of Motors—Development of A. C. and D. C. Motor Types—Substitution of Electric Transmission for Mechanical Transmission in Machines—High-Frequency Motors—Motor Control

By WILLARD C. JOHNSON,[1] SAN FRANCISCO, CALIF.

BECAUSE of their interdependence, the design and application of electric motors may well be considered together. In one case the development of a new design will make new applications possible, while in another, new designs will be worked out to meet the requirements of a desired application.

Design and production departments are working together as never before to the end that structures shall not only be entirely adequate for the purpose intended, but that their designs shall be such as to lend themselves to economic manufacture.

Use of Structural Steel

One of the most recent major design changes has been the substitution of structural steel for castings, and the fabrication of this material by the electric arc.

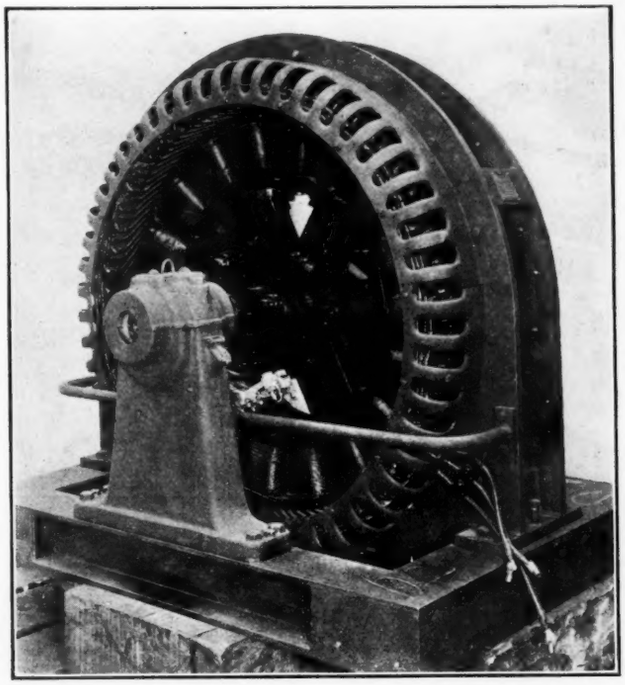

Fig. 1 Slow-Speed Synchronous Motor Using Fabricated Steel in Place of Castings

The use of punched, pressed, and rolled steel in place of castings has been on the increase in the electrical industry for a long time. Rolled-steel motor frames have been in use for more than seventeen years, antedating even the use of electric-arc welding with the metal electrode. The general application of fabricated steel in place of castings in the construction of large motors, however, is relatively new.

A complete line of slow-speed synchronous motors has been on the market for some two and a half years, in which—with the exception of bearing pedestals and collector rings—no castings are used. The machines have been so successful that during the past year this type of construction has been extended to all large alternating-current motors and to medium and large direct-current motors. (See Fig. 1.)

At the present time there seem to be only two classes of structures where the use of fabricated steel will not be economic. For small structures produced in large quantity, such as small and medium-sized alternating-current-motor frames and brackets, metal patterns can be used with automatic molding. The machining operations are largely done on highly developed automatic machines. Here the casting has so far proved to be the more economic structure.

Structures of such contour that they are not readily made from available commercial shapes, comprise the second class. Fabricated-steel pedestal bearings, for example, have so far shown much higher costs than cast designs.

Fabricated-steel structures can be made to closely duplicate in appearance the cast structures which they supersede. If the designer has done his work well, however, this will not in general be true. The newer material will be used to the best possible advantage, considering its own peculiar properties, and with as little reference as possible to the limitations of older cast designs.

Experience has already shown that thoroughly sound and satisfactory designs are possible with fabricated steel. Accepting this, it would be well to consider some of the advantages of this type of construction.

Considering the large, immediate investment required in tools, and shop rearrangement, it is not probable that the substitution of structural steel for castings will result in any immediate reduction in costs. An ultimate reduction may be expected, however, not only because of the absorption of development costs but because of the better and more efficient methods which are bound to come with further experience.

Shorter deliveries are possible with the steel construction, not only because of the complete elimination of pattern-shop and foundry time, but also because greater concentration of responsibility in the manufacturing organization can be had, resulting in greater efficiency and quicker production.

The fabricated-steel design is also much more flexible. Today's design can easily be made to incorporate today's knowledge, which, were the design tied down to available existent patterns for a cast structure, would be either difficult or impossible.

Reduced Human Labor

A trend of today, which is by no means peculiar to the electrical industry, is the continued cutting down of the human labor required in the manufacture of any given article. The utilization

[1] Westinghouse Electric & Manufacturing Company.

Presented at a meeting of the San Francisco Section of the A.S.M.E., San Francisco, Calif., February 28, 1929.

of electrical energy has been one of the principal means to this end. The electric motor has continued to help in this direction; first, by a marked reduction in the already small maintenance which it requires; and second, by new developments which have made its use possible today, where previously some less economic type of drive would have been required.

The "sealed-sleeve" bearing (Fig. 2), a type of housing which even under the most adverse conditions keeps the dirt out and the oil in, and only requires the addition of new oil at intervals of 6

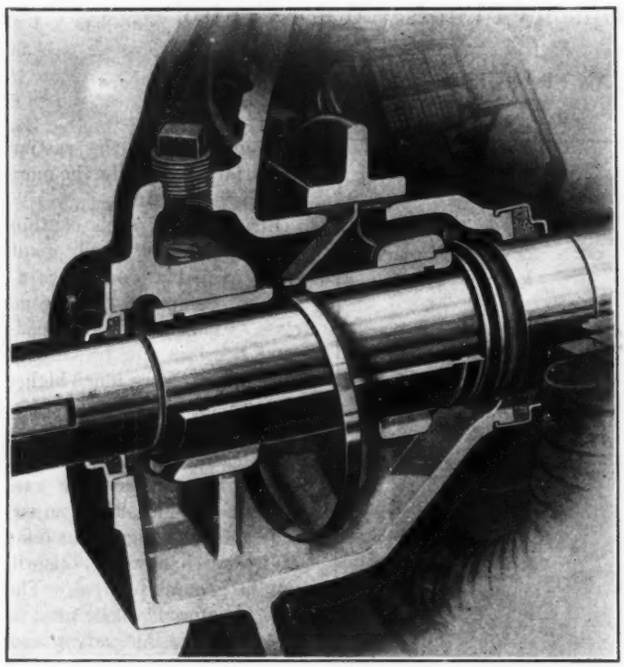

FIG. 2 "SEALED-SLEEVE"-BEARING TYPE OF HOUSING APPLIED TO AN INDUSTRIAL MOTOR

months to a year, is a development of the first type. A motor with this type of housing has been run for $4\frac{1}{2}$ years without adding any new oil. Improvements in the impregnation and treatment of motor coils have been developed which make them highly resistant to the action of moisture, chemical fumes, and oil. High-frequency testing equipment has been developed for the detection of short-circuits between turns in completed motor coils. An assurance of perfect coils, not previously possible, is the result. A process has been developed for the cementing together of the fish paper and treated cloth used for slot insulation. This serves to eliminate air pockets and resultant hot spots.

The totally enclosed fan-cooled motor (Fig. 3) is a development of the second class. This is now available for both alternating and direct current, the size of the totally enclosed motor of this type being practically the same as the open motor up to approximately 50 hp., and increasing to double the size at the upper limit of 100 hp. A more economic drive is therefore available for exceptionally dirty places.

Explosion-tested equipment has been developed for use in gaseous mines, around oil refineries, and in gas plants.

Protected-type oil-well motors (Fig. 4) and control have been brought out for use on wells that may produce gas. Here the wound-rotor induction-motor slip rings are enclosed in a sealed pot, and the controllers are oil-immersed.

SQUIRREL-CAGE INDUCTION MOTORS

The development of the squirrel-cage motor suitable for line-voltage starting has been so rapid in the past few years as to almost entirely displace the older reduced-voltage-starting motor in sizes up to 30 hp. The Class I "Linestart" motor is available in that range of sizes, to meet the National Electric Light Association starting-current limits. This motor has torques suitable for general-purpose application and with performance equal to or better than that of the older types.

In general, larger motors with performance suitable for general-purpose application will not meet the N.E.L.A. starting-current limits when started on line voltage. However, as this limit is in many cases not the determining factor, a series of squirrel-cage induction motors in ratings through to 1250 hp. and in speeds up to 3600 r.p.m. on 60 cycles has been brought out, which are designed for starting on full voltage with relatively low starting currents. (Fig. 5.) High-head centrifugal pumps for

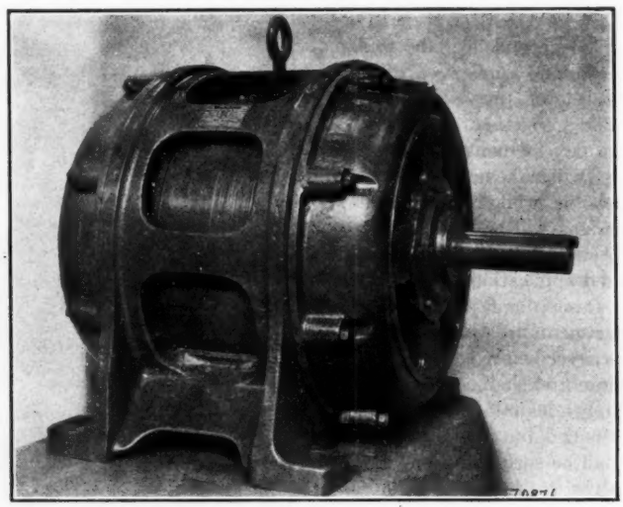

FIG. 3 TOTALLY ENCLOSED FAN-COOLED MOTOR

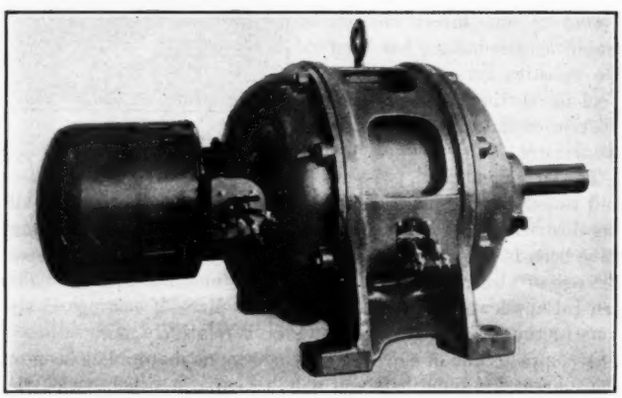

FIG. 4 PROTECTED-TYPE OIL-WELL MOTOR FOR USE ON WELLS THAT MAY PRODUCE GAS

pumping oil and boiler feedwater and turbo-blowers run at speeds calling for these large, high-speed motors.

Class II "Linestart" motors, that is, squirrel-cage motors to give high starting torques, are available for such applications as air compressors and ammonia compressors started loaded. For such service these motors have almost completely taken the place of the more expensive and less simple slip-ring motor. The Class II motor usually has a rotor of the so-called double-deck construction. The die-cast aluminum rotor (Fig. 6) particularly lends itself to this construction, as practically any bar shape desired can be readily made.

With the "Linestart" motor has come the simple push-button-operated contactor switch or "Linestarter" (Fig. 7). The thermal type of overload relay usually used with the "Linestarter" makes possible dependable overload protection for the motor. The principle of the Deion circuit-breaker is being utilized in the grid-type arc quenchers used on Linestarter contactors (Fig. 8). These arc quenchers multiply the breaking capacity of the contactor several times, and result in reduced maintenance and longer life under normal operating conditions.

SYNCHRONOUS MOTORS

Synchronous motors are still considered by many as machines with "prima donna" temperaments, the use of which should be avoided wherever possible. In the past there was much to support such a view. Today, however, the synchronous motor offers a simple, reliable, and trouble-free drive for practically any application where a constant-speed motor will meet the requirements.

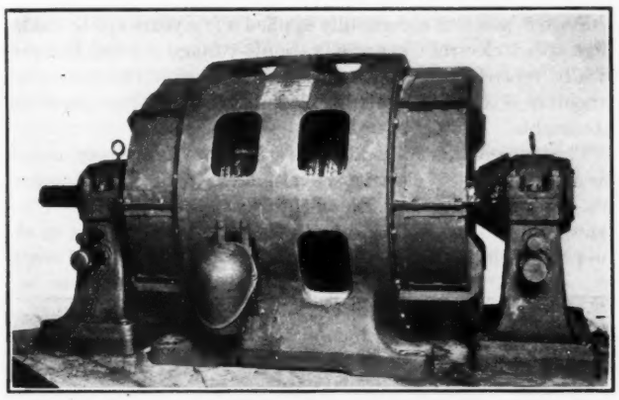

FIG. 5 SQUIRREL-CAGE INDUCTION MOTOR (1000 HP., 60 CYCLES, 3600 R.P.M.) FOR STARTING ON FULL VOLTAGE

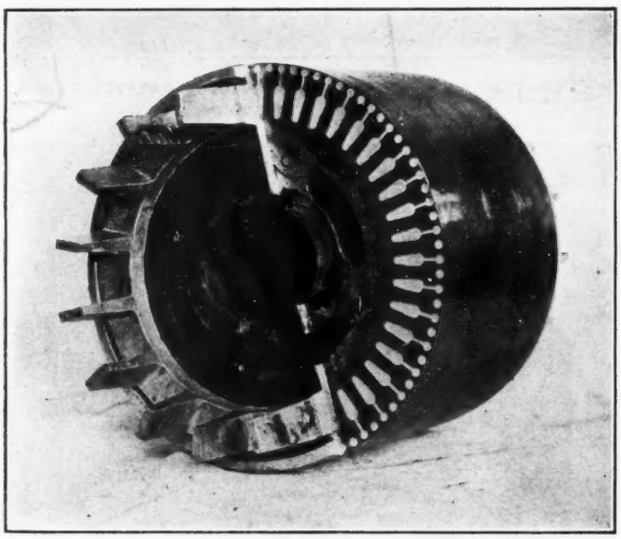

FIG. 6 DIE-CAST ALUMINUM ROTOR OF DOUBLE-DECK CONSTRUCTION

One of the earliest very general applications of synchronous motors was for direct coupling to air compressors. The compressor was started unloaded, so that even the earlier synchronous motors had adequate starting and pull-in torques, and (giving no consideration at all to the matter of power factor) the synchronous motor at the slow speeds required gave very much better efficiencies than the equivalent induction motor. In addition, at slow speeds the cost of the synchronous motor tends to be less than that of the induction motor.

Until recent years, however, synchronous motors have not been available with starting and pull-in torques adequate for most applications, and the control required has in general been quite complicated.

It should be understood that the synchronous motor is usually started as a squirrel-cage induction motor, and the starting torque is therefore subject to the same laws that govern in the case of the induction motor. The pull-in torque, however, is almost entirely a matter of the maximum speed attained as an induction motor. In other words, the lower the slip or the more nearly synchronous speed is approached as an induction motor, the higher will be the pull-in torque.

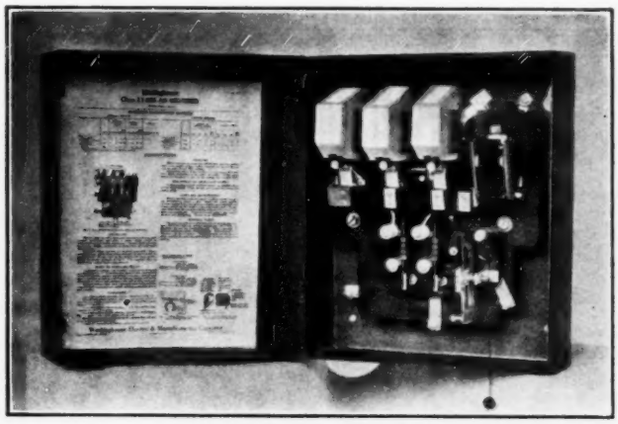

FIG. 7 SIMPLE PUSH-BUTTON-OPERATED CONTACTOR SWITCH OR "LINESTARTER"

All of the research and development of the past few years which has resulted in improved starting torques for the squirrel-cage induction motor, has in the main also been applicable to the synchronous motor. In the squirrel-cage induction motor, however, any change that is made in the winding to improve starting conditions will also have an effect on the running performance, while the squirrel-cage starting winding on a synchronous motor has practically no effect on its performance at synchronous speed.

The first successful application of synchronous motors to heavy starting loads consisted in starting the synchronous motor light or disconnected from the load, and then—when it had pulled into step—connecting it to the load by means of a magnetic clutch. This made the pull-out torque of the synchronous motor, which is high, available as a starting torque. This development was carried further in the "clutch-type" synchronous motor where a suitable magnetic clutch was incorporated within the motor itself, and motors of this type have been successfully applied for several years past.

Today the "Simplex" synchronous motor (Fig. 9)—where no clutch is used—is capable of producing adequate starting and pull-in torques for practically any application which may be made of it. This is accomplished by the combined action of a separate squirrel-cage winding and the field winding itself. The field winding, which is of low resistance, has an external resistance connected in series with it at starting. This external resistance is cut out in steps as the motor accelerates, and is finally all cut out before the direct-current field is applied and the motor pulled into step. This combination gives the high starting torque which goes with a high-resistance rotor, and the

low slip and therefore the high pull-in torque which goes with a low-resistance rotor.

Today most synchronous motors are started by applying full line voltage, thus making available a very simple type of automatic starter which not only connects the motor to the line at the proper time, but also automatically applies the field when maximum speed as an induction motor has been reached.

Centrifugal pumps are now being quite largely driven by synchronous motors. Synchronous motors aggregating some 100,000 hp. have been applied to roll drive in the steel industry, two 5000-

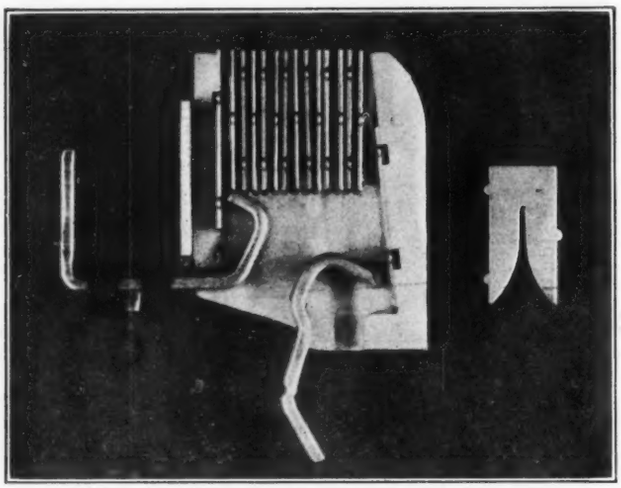

Fig. 8 Grid-Type Arc Quenchers Used on Linestarter Contactors

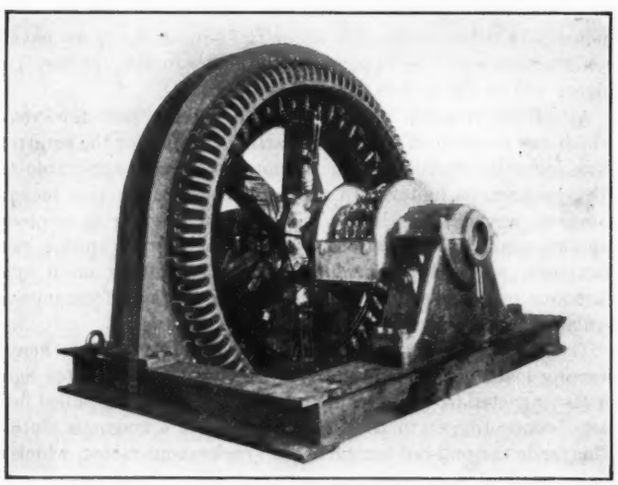

Fig. 9 Simplex Synchronous Motor

hp. motors running at 82 r.p.m. having been recently delivered for roll drive at Pittsburgh, Calif. These motors are of fabricated-steel construction.

In general, then, it may be stated that synchronous motors offer a simple and reliable drive for practically any constant-speed application. The correction of power factor, which the synchronous motor makes possible, will in many cases be the determining factor. In addition to this, however, slow-speed synchronous motors will usually have higher efficiency and will cost less than the corresponding induction motors, and high-speed synchronous motors in the larger sizes will usually have enough higher efficiency than the induction motor to warrant their installation where the load factor is high.

Direct-Current Motors

Today practically all electric power is generated and transmitted as alternating current. Notwithstanding this fact, however, the application of direct-current motors is constantly being extended. This of course is because of the greater control flexibility which the direct-current motor offers for many applications.

The control of the motor speed, by varying the voltage applied to the motor armature, is by no means new, but it is only within the past few years that variable-voltage control has been developed to its present stage of perfection.

With this type of control, a separate generator is required for each motor. The immediate power source, therefore, is a motor-generator set which usually consists of an alternating-current motor driving one or more direct-current generators.

Since it was first successfully applied a few years ago to modern high-speed electric elevators, variable-voltage control has practically replaced the older rheostatic control. The result is a smoothness of acceleration and flexibility of control not previously obtainable.

This type of control is also used for reversing planer motors, large mine hoists, electric shovels, large reversing motors for rolls in steel mills, and Diesel-electric ship propulsion. Where motor reversal as well as speed control is necessary, as in ship propulsion and reversing steel-mill motors, this type of control

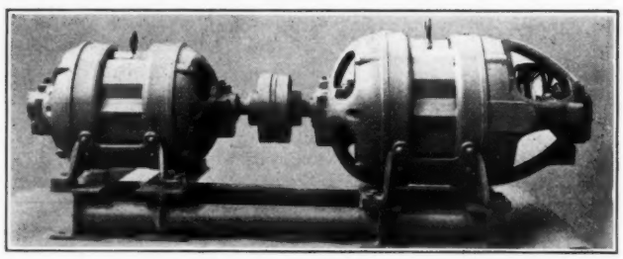

Fig. 10 Induction Frequency Changer to Supply Current at High Frequency

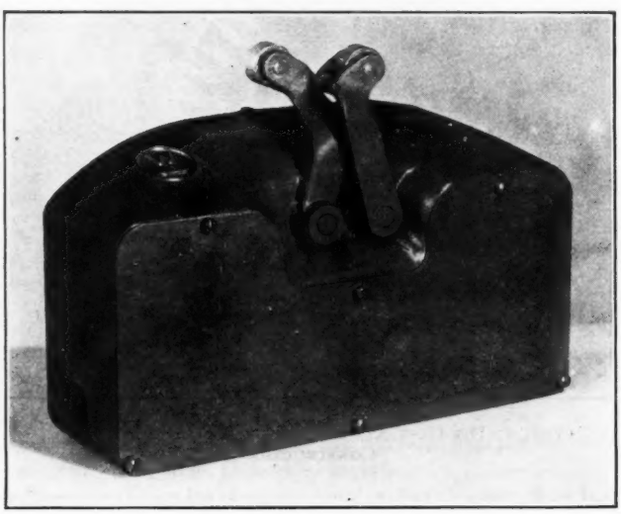

Fig. 11 Platen Limit Switch Used Instead of Master Switch for Machine-Tool Operation

greatly simplifies the problem, as main-line current does not have to be interrupted.

A motor-generator locomotive recently pulled the first train through the new Cascade Tunnel of the Great Northern, and the new 10,000-ton freighters for the United States Shipping

Board have direct-current motors driving their propellers, with a normal rating of 4500 hp. and a maximum rating of 8000 hp.

ELECTRIC TRANSMISSION WITHIN THE MACHINE

One of the outstanding advantages of electric power, which was realized with the advent of the alternating-current system, is the economy with which it can be transmitted over long distances.

The earliest application of electric power usually consisted in substituting an electric motor for a steam engine, the existent mechanical transmission within the plant itself remaining unchanged.

Some 20 years ago, individual motor drive began to be much talked about, as it was realized that the economy of electric transmission within the plant itself offered worth-while savings. Electric transmission was in general more efficient than mechanical transmission; and, with each machine driven by its own motor, plant arrangement could be determined by production requirements, unhampered by such considerations as the relatively fixed locations of lineshafts and belting.

One of the trends of today is the substitution of electric transmission for mechanical transmission within the machine itself. An outstanding example is the paper machine. The various elements of the machine must run at speeds which, when once set, will not vary; but the relative speeds of the different elements must be capable of adjustment to obtain the necessary draw. In addition, it is usually necessary to be able to vary the speed of the entire machine over a considerable range, to take care of various grades of paper. The usual drive formerly consisted of a variable-speed steam engine driving a lineshaft, the latter being connected to the various machine elements by belts running over cone pulleys. When motor drive was first used, the motor simply replaced the steam engine and the mechanical transmission remained the same. At this time newsprint paper was being made at a maximum paper speed of about 600 ft. per min. It was realized that, as far as the paper machine itself was concerned, this speed could be materially increased, but at higher speeds the mechanical transmission fell down. An obvious answer was an individual motor on each section of the machine, provided a suitable control could be developed to insure that the various motors would properly operate together. The control was developed and the speed for the manufacture of newsprint doubled almost at once. This was several years ago and improvements are still being made, so that today any speed limitations are in the driven machine, not the drive.

Another example is the modern woodworking machine, where each cutter is driven by its own motor, quite generally built into and made a part of the machine. This has made available cutter speeds which were not previously obtainable.

HIGH-FREQUENCY MOTORS

The usual alternating-current supply circuit has a frequency of 60 cycles, and at this frequency the maximum induction-motor speed is slightly less than 3600 r.p.m. Small portable tools, and sometimes the cutters on woodworking machines, require higher speeds than this. To meet this requirement, an induction frequency changer (Fig. 10) has been developed to supply current of a sufficiently high frequency to obtain the desired speed. The usual frequencies for this sort of service are 120 and 180 cycles.

MOTOR CONTROL

The definite trend in motor control is to substitute the push-button or master-switch-operated automatic starter or controller for the manually operated device. (See Fig. 7.) With this has gone the continued simplification and improvement of automatic control. The simplicity of today's control, even where many complex operations are performed, is outstanding. It may be stated as a fact that the number and complexity of the parts in any given device bear an inverse ratio to the brains employed in its design.

If this be true, today's control devices certainly speak well for the quality of the brains which have been employed in their design.

Volume Changes During Solidification of Metals and Alloys

OWING to experimental difficulties, the various methods in use for determining the changes in volume which take place in pure metals and their alloys, especially during their solidification, do not give very concordant results, even for materials of low melting points. Dilatometer determinations seem to be suitable when the specimen is cooled from below upward in its container; observation of the contraction of cast bars and the buoyancy-balance methods, like most of the others, become unreliable at high temperatures. An account of measurements conducted by Mr. W. E. Goodrich, M.Met., in Professor Desch's laboratory in Sheffield, on behalf of the Die Castings Committee of the British Non-Ferrous Metals Research Association, on metals of low fusibility, viz., tin, lead, bismuth, antimony and their alloys, was given at the Faraday Society on October 31.

Pure tin was found to contract suddenly by 0.34 per cent at 161 deg., but this contraction was not observed in rich tin alloys. Of the tin-lead alloys, that with 52 per cent of tin showed the minimum contraction during solidification, of 2.28 per cent, pure tin and pure lead contracting by 2.97 per cent and 3.85 per cent, respectively. The well-known expansion of bismuth during solidification, between 268.3 and 268.0 deg. cent., was found to amount to 3.47 per cent, and to take place actually during the solidification, and not in the liquid. Tin-antimony-copper alloys with 92 per cent of tin and 8 per cent of antimony were particularly studied; the addition of copper, especially when above 1.5 per cent, increased the contraction during solidification. In the tin-lead-antimony alloys the Sb percentage was kept at 10, and the Pb varied between 0 and 30 per cent. As the lead was increased, the contraction, due to the solidification of the eutectic, rose to 1.1 per cent, while the total contraction reached a maximum of 8 per cent, decreasing again on further addition of lead. The supposed expansion of babbitt and type metals on solidification would seem to be only apparent, and due to a kind of sweating out of certain constituents. Pure zinc contracted by 4.48 per cent on freezing, and expanded by 4.69 per cent on melting. The addition of 3 per cent of tin and 5 per cent of copper increased these volume changes to 5.8 and 6.16, and even to 7.83 per cent in the presence of 10 per cent of tin, but the further addition of aluminum lowered these values.

The behavior of these alloys cannot be predicted from their chemical compositions. The metals occur in several modifications, eutectics form and freeze out at different temperatures, and cracks between crystals and intergranular fissures retain gases and liquids. Aging takes place, moreover, and the cubical expansion coefficients depend greatly upon the heat treatments, which are difficult to control.—*Engineering*, Nov. 15, 1929, p. 659.

Industrial Preparedness

The Supply Problem Confronting the Ordnance Department of the Army, and the Procurement Organization That Has Been Devised to Handle It

By WM. M. MOODY,[1] SAN FRANCISCO, CALIF.

THIS paper will consider industrial preparedness chiefly from the standpoint of the problem confronting the Ordnance Department of the Army in peacetime preparation for a major emergency. Those of us connected with the Army realize that it takes far longer to make munitions than to make soldiers. However, the average citizen requires considerable educating, and it will probably be admitted that the American people, as a body, are notoriously indifferent to danger and foolishly optimistic regarding our industrial potentialities. Therefore this paper will attempt to point out the deplorable condition we should be in if war were declared tomorrow. This condition will probably remain until public opinion forces legislation to provide for proper reserves and complete industrial preparedness.

By way of background there are a few charts which will give a basic color to the discussion. Fig. 1 shows the discrepancy between mobilization and rate of supply. The mobilization curve is an ideal curve which the General Staff has set down as desirable in meeting a major emergency. The supply curve indicates the possibilities of industry, assuming that all possible planning has been done. The area between the two curves indicates the impossibility of manufacturing munitions to meet immediate requirements. This area, therefore, must be filled by reserves. If there are not sufficient reserves to accomplish this, there are two solutions open. The first is to delay mobilization and bring down the upper curve. This is of course a compromise and may mean the loss of a war, or at the least a long period of defensive engagement. The second solution, and this is our present problem, is to accelerate the manufacture of munitions and move the lower curve to the left. This solution offers a chance for real constructive work—industrial preparedness.

The Army's Sources of Supply

The Army is supplied by several supply departments. The Quartermaster provides clothing, subsistance, horses, vehicles, etc. The Engineer Corps provides instruments, contracting equipment, military railways, etc. The Air Corps supplies airplanes and related equipment except armament. The Chemical Warfare Service supplies special chemicals, loading of chemical shells, and gas masks. The Medical Corps provides the ordinary medical and hospital supplies. The Coast Artillery Corps is charged with submarine mines and related equipment. The Signal Corps provides telephones, radio, and other communication equipment. The Ordnance Department provides all arms, ammunition, tanks, tractors, and fire-control instruments. As to the volume of supplies, it is interesting to note that the increase of expenditure for war years over peace years by the War Department as a whole was from one hundred million to fourteen billion dollars annually—an expansion of 140 times. On the other hand, the expenditures of the Ordnance Department increased from ten million to four billion annually—an expansion of 400 times. Therefore the ordnance problem is one of securing not only an immense volume of material but items of a totally non-commercial nature, whereas the bulk of the material supplied by the other branches is of a more or less commercial nature.

The District Plan of Procurement

In setting up an organization to handle this volume, instead of attempting to organize a four-billion-dollar office in Washington or New York, fourteen districts have been formed with the attempt to divide the load more or less equally. The district plan is designed not only to simplify procurement by decentralization, but also to spread manufacture in such a way as to avert possible disaster due to invasion of one or more manufacturing centers. Fig. 2 shows the location of these districts. Without this district plan a vital piece of equipment being manufactured solely in Hartford or Bridgeport would present a desperate problem to the Army if this area were threatened by an enemy invasion from the St. Lawrence through the Champlain Valley. Under the new plan any order so threatened could be shifted bodily to some other district having a similar order, and would require merely the expansion of an existing program and not the initiation of new facilities. In effect, the district plan is similar to that of a holding company (corresponding to the Chief of Ordnance) with many subsidiary companies (corresponding to the separate districts), and, briefly, this organization gives centralized control with decentralized operation. The requirements of any item are settled by the General Staff forming the mobilization plan and the standard equipment tables. Each district chief surveys the available facilities, and after conferring with the Chief of Ordnance the total requirements are apportioned to the several districts. Any of these apportionments are of course subject to change from year to year as industrial conditions vary. Following the apportionment of a certain quantity of a certain item to a district, the district chief requests that a certain industry be allocated to the Ordnance Department and then issues an accepted schedule of production to that

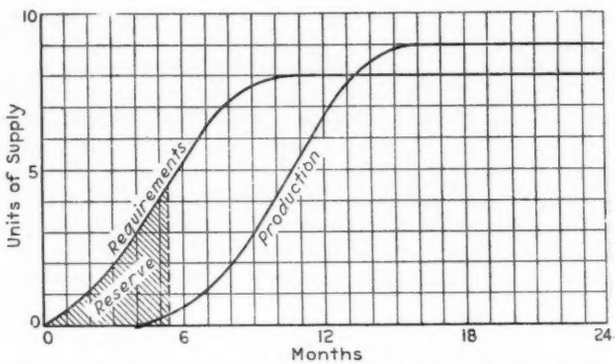

FIG. 1 CHART SHOWING DISCREPANCY BETWEEN MOBILIZATION AND RATE OF SUPPLY

[1] Major, Ordnance Reserve Corps, U. S. Army. Vice-President, Pelton Water Wheel Co. Mem. A.S.M.E.

Presented at a meeting of the San Francisco Section of the A.S.M.E., San Francisco, Calif., August 22, 1929.

company. A company having once been allocated to the Ordnance Department by the Assistant Secretary of War will not be approached by any other supply branches of either the Army or the Navy, and cannot even *undertake* work for other branches without the consent of the Ordnance Department.

ACCEPTED SCHEDULES OF PRODUCTION

Fig. 3 is a copy of a sample accepted schedule of production. This document corresponds in the commercial sense to the ordinary purchase order which will be confirmed at any subsequent date by a formal contract. The contract will not be touched upon in this paper, as it is a subject by itself. However, briefly, the contract form as at present adopted is known as the "adjusted-compensation contract," and provides payment of a manufacturer's total cost with a fixed profit and provision for bonus for increased efficiency or penalty for decreased efficiency. The particular accepted schedule of production shown in the figure covers 75-mm. gun carriages and is reproduced from an actual schedule issued to and accepted by the Pelton Water Wheel Company. It not only shows the total order but indicates delivery dates and gives certain information relative to the order. It will be noted that it covers a certain drawing and drawings listed thereon, and it is of interest that there are listed 376 drawings, of which 67 are assemblies and 309 are details. These drawings represent 378 items or 930 pieces for one carriage. Therefore the order given for 600 carriages plus the spare parts which are included, involves a total production of over a million pieces.

Following the acceptance of this schedule by the manfacturer, it is the intention that he shall proceed with the preparation of what is termed a "factory war plan." In the first place, for each piece there must be estimates made of labor and material in order to obtain an estimated cost. The material source should be investigated, and the effect of war on that source. Any necessary transportation should also be taken into account, and in estimating the labor, machine-tool time should be segregated in order that any additional machine-tool equipment can be included. After the costs of the pieces have been figured, it is very desirable that the jigs and fixtures be designed or at least that some estimate be made of them. One of the greatest problems, probably, is that of manufacturing gages. Of course the local ordnance office will have its own inspection gages, but the manufacturer will also need inspection gages as well as the actual gages for all important operations. In some cases a fixture can be designed so that it will be a gage for one or more previous operations. However, this is true for only a very small percentage of cases, and almost certainly the crucial problem will be that of obtaining sufficient gages in time when desired. Material is purchased on Ordnance specifications, and it is interesting to note that on this particular order there are 14 different kinds of steel. From the estimated hours the number of men required can be calculated, and the source of such labor should also be taken into account. If all costs for these many items are then estimated, it will be possible to plan some sort of production schedule which will show whether the deliveries specified can be met. Probably the first attempt will differ widely from the specified schedule, as a consequence of which the plan must be gone over in an endeavor to cut down the time wherever possible, and if necessary the Ordnance Department must be appealed to in order to revise the accepted schedule, although this should be a last resort, as the result is of course obvious.

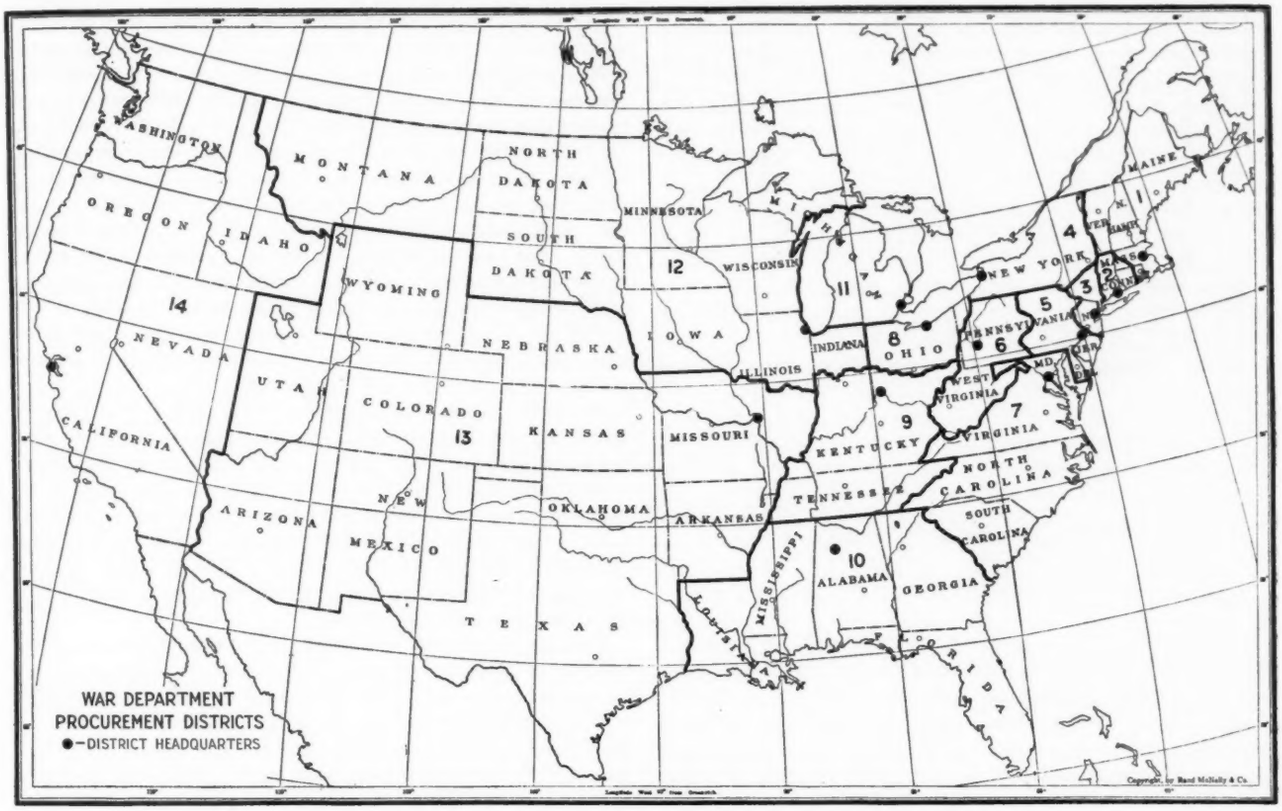

FIG. 2 WAR DEPARTMENT PROCUREMENT DISTRICTS
(Black circles indicate location of district headquarters.)

CONFIDENTIAL

ACCEPTED SCHEDULE OF PRODUCTION NO. C-41

FOR Carriage, 75mm Gun, M1

THE FOLLOWING QUANTITIES OF THE ABOVE NAMED ARTICLE ARE ALLOCATED FOR MANUFACTURE TO The Pelton Water Wheel Co. San Francisco, Calif. IN THE EVENT OF A MAJOR EMERGENCY

UNIT One DATE Aug. 15 1928 REVISED

MONTHS AFTER PROCUREMENT BEGINS	QUANTITIES BILLED AND DELIVERED TO CARRIERS	MONTHS AFTER PROCUREMENT BEGINS	QUANTITIES BILLED AND DELIVERED TO CARRIERS
1		13	42
2		14	42
3		15	42
4		16	42
5		17	42
6		18	42
7		19	42
8		20	42
9	10	21	42
10	18	22	42
11	26	23	42
12	42	24	42

TOTAL QUANTITY COVERED BY THIS ORDER 600

REMARKS

Drawings: 2-224-1 and drawings listed thereon.
Specifications: 51-21-25 Not Available
Technical Information Center: Rock Island Arsenal.

CHIEF
SAN FRANCISCO ORDNANCE DISTRICT

ARTICLE Carriage, 75mm Gun, M1

FIG. 3 SAMPLE ACCEPTED SCHEDULE OF PRODUCTION

Having reconciled the accepted schedule and the predicted schedule and estimated the total costs, the contract can now be drawn and the factory plan is complete. Of course this plan should be gone over in detail periodically and revised when necessary, but even so, all that has been done thus far is a mass of paper work and means only part of the battle. A much larger step can be taken, and rightly should be taken, in order to further our industrial preparedness. This particular step is termed the "educational order." It was shown early in the paper how it is necessary to build up our reserves, and if this building up can be done by small orders placed on a cost basis, in peace times, with the manufacturers who have accepted schedules of production, it will not only give us the required reserves but will accomplish many other objectives. Such an educational order would in the first place give an accurate record of costs, and would enable shop drawings, specifications, etc. to be prepared and tried. It would give the manufacturer an opportunity to actually build jigs and fixtures and save that much time during a major emergency. Probably the greatest of all benefits that would accrue would be the accumulation of manufacturing and inspection gages. Of course these small orders would be very costly as they could not be turned out on a purely production basis, and would of necessity bear the cost of fixtures, gages, and all such overhead expenses. However, if all pertinent industry throughout the country could be equipped with all such overhead material, the production of Ordnance material in the desired quantities could probably be effected three to six months earlier than as now planned. In short, such a saving might mean the difference between a successful war of short duration and a long-drawn-out conflict or actual defeat.

Recent Developments in the German Iron and Steel Industry

PERHAPS the most interesting mechanical developments lie in the making of seamless tubes. At the present time the Mannesmann Tube Company extrude seamless tubes up to 3 in. in diameter, and what is more, of stainless steel. Each tube is extruded vertically downward by means of a 4000-ton press at an enormous speed, is moved sideways, and is freed from the die by a rotary knife.

Several expanding mills are being developed. The Mannesmann Tube Company have a mill which is similar to the Stiefel mill, but uses a tension mandrel instead of a compression mandrel.

In a new piercing mill advertised, two rolls on each side take the place of the present piercing-mill roll; two rolls form the converging part of the pass, while two others form the diverging part. Up to the present time only small sample tubes have been rolled.

Pipes, boiler drums, and reaction chambers of more than 24 in. diameter are either hollow forged, welded, or rolled by a new process. In Germany boiler drums are frequently welded to two half-shells. For such drums boiler makers are allowed 90 per cent of the strength of an integral shell, whereas here in the United States such procedure is absolutely prohibited under the code of the A.S.M.E. The welded shell is turned and bored, and tested hydraulically. Then the ends are wedged down, and the drum is tested once more with hydraulic pressure.

However, the cost of welding sections 3 in. or more thick is quite high. To get away from this troublesome process, one steel works has developed a new one, in which ingots are cast hollow over a collapsible core. The hollow ingots are then elongated by means of a special rolling mill which applies a number of small rolls on the outside and an equal number of rolls on the inside, set slightly on a skew so that they both rotate the ingot and feed forward. Seamless tubes up to 40 in. diameter and 30 ft. long have been rolled by this process.

The largest manufacturer of seamless tubes in Europe has been experimenting with several hundred corrosion and rust protection means and has at last settled on a new flexible lacquer which has most remarkable properties. It is virtually hammer- and acid-proof, withstanding successfully even boiling hydrochloric acid. The pipes to be coated are pickled, rinsed, dried, and dipped in the lacquer, which is a phenol-formaldehyde condensation product; they are then baked, and are ready for shipment. In places where pipes are cut, welded, or threaded, lacquer is applied with a brush and baked with a blow torch.

This lacquer is also being considered for structural material and promises to be a severe competitor of the new rust-proof structural steels that contain copper and chromium. It is likewise a competitor of tinplate for cans, buckets, dishes, basins, etc., and of zinc and lead not only for pipes but also for roofing sheets.

With regard to heat engineering, one of the greatest steps in furnace work is the use of mixed blast-furnace and coke-oven gas, and the preheating of such mixtures in regenerators. For many years it was an axiom that rich gases must not be preheated, because they would break up and deposit carbon, thereby making the gas poor and clogging up the regenerators. However, it has been found in Germany that two volumes of blast-furnace gas and one volume of coke-oven gas form a mixture which can very well be preheated in a regenerator. The hydrocarbons in the coke-oven gas are cracked in the heat, and the carbon particles impart luminosity to the mixed gas. Only a small amount of carbon is deposited in the regenerators, and it is always burned out and off the bricks during the reversing.—W. Trinks in a paper before the A.S.M.E. Iron and Steel Division, Akron, Ohio, October 21, 1929.

The Influence of Standardization in the Mechanical Industries

Report of Symposium Held at Purdue University During the Third Summer School Conducted by the S.P.E.E., July, 1929

BELIEVING that the instructing staffs of our technical schools and colleges should be kept well informed concerning the progress which standardization is making in the industries of the country, the committee in charge of the program for the third summer school conducted by the Society for the Promotion of Engineering Education requested the A.S.M.E. Standardization Committee to make the necessary arrangements for a conference or symposium on this subject. The A.S.M.E. Committee was glad to comply with this request, and largely through the efforts of its chairman, Collins P. Bliss, a program of three papers was prepared and William S. Monroe, a member of the Committee, agreed to preside. The conference was held on the evening of July 8, and was attended by approximately ninety members of the summer school and guests. In his opening remarks, which are given below in abstract, Chairman Monroe referred briefly to the part which the A.S.M.E. has played in the development of interest in standardization in the United States, and the organization of a satisfactory procedure.

The A.S.M.E. and Standardization Under the A.S.A.

By WILLIAM S. MONROE,[1] CHICAGO, ILL.

WHILE this meeting is intended to give you some idea of the way in which standardization is being applied every day in three distinctly different mechanical industries of our country, I shall take a few minutes of the available time to sketch hurriedly the historical background for this movement in the United States. I believe that The American Society of Mechanical Engineers is entitled to the credit for having originated standardization activities in this country. As early as 1889, James W. See, of Hamilton, Ohio, delivered a paper before the A.S.M.E. in which he called the Society's attention in detail to the great need of registration of manufacturing standards. It was Mr. See's idea that the Government should create a department to act as a registrar for standards but not to do the standardization work.

Acting upon his suggestion, three members of the Society were appointed as a special committee to take under consideration the subject of a Governmental bureau for the recording of standards. This committee reported in November, 1889, recommending the Society's approval of the installation of a Government bureau for this purpose. A bill was proposed by the committee to make the necessary provision for some such set-up. It was not, however, reported out of committee and died at the expiration of the Congress.

This A.S.M.E. committee appointed in 1889 consisted of Messrs. James W. See, Coleman Sellers, and Oberlin Smith, and was called the Committee on Standards. Later its membership was increased from 3 to 5, and it is still known as the A.S.M.E. Standardization Committee. Its members are appointed by the President of the Society for a term of five years, one each year. The work of this A.S.M.E. Standardization Committee increased gradually year by year up to the time of the World War. The pressure for the production of munitions and other war equipment emphasized the need of standardization in many fields, and in 1918 the A.S.M.E. Standardization Committee, under the leadership of its able chairman, Henry Hess, had an active part in the origination of the American Engineering Standards Committee (American Standards Association), which is now recognized by the national engineering organizations as well as by industry in general as the coordinating organization for standardization of the United States. Its membership now includes forty-four engineering societies, manufacturers' associations, and Government bureaus.

As the work of the A.S.A. is at the present conducted, any group of men in or out of the member-organizations of the American Standards Association can originate a standardization project by presenting it to the standards committee of any one of the organizations in the A.S.A. Projects are often started by a group of manufacturers, and in some cases have been suggested by members of some users' organizations or by departments of the U. S. Government. But eventually the suggestion is usually endorsed by the standards committee of one of the responsible organizations in the A.S.A. and submitted by such committee to the A.S.A. for approval.

When necessary, a formal conference on any project can generally be called within a month from receipt of an official letter requesting development of a given standard. This conference, if it is successful, determines, through the work of a temporary committee, the scope and recommendation as to what organization should be made sponsor. This report goes back to the A.S.A. When the sponsor organization has been appointed and the work accepted by the standards committee of that organization, letters are sent to all national organizations representing manufacturers, consumers, and general interests which are in any way concerned in the development of the standard in question, inviting them to appoint official representatives on the sectional committee being organized to develop this project.

As you can well understand, it frequently takes a long time and many meetings of such sectional committees and sub-committees to work out of these standards. In the development of a standard or set of standards there are a considerable number of persons who have a right to be heard in one way or another and whose opinions have to be considered, and the work of harmonizing the various ideas is a job of major proportions and often involves engineering skill as well as great personal tact on the part of the members of the sponsor committee.

At the present time the A.S.M.E. is sponsor or joint sponsor for twenty-six sectional committees under the procedure of the American Standards Association. The total number of members on these committees is over fifteen hundred. It is interesting to note that approximately 200 societies and associations are now cooperating with the A.S.M.E. in its standardization

[1] President, Sargent & Lundy, Inc. Mem. A.S.M.E.; Mem. A.S.M.E. Standardization Committee.

work, which covers a great variety of mechanical projects. So far the A.S.M.E. has approved and published twenty-five American Standards and American Tentative Standards, and many others are in process of development.

From the standpoint of the engineer and the scientist, it is possible to carry standardization too far. I believe that standards should never be considered final, and should in all cases be subject to periodic revision. Standards should not hamper initiative, inventiveness, and originality in new developments. Great improvements are rapidly being made in metallurgy and in machine-shop practice, and many standards will have to be revised to keep up to date with such improvements. The A.S.A. and its procedure, being permanent, will be of great value in the future to industry, not only in developing new standards but also in serving as an organization through which these standards can be periodically revised and improved.

Influence of Standardization in the Heat and Power Industry

BY A. M. HOUSER,[2] CHICAGO, ILL.

THE pipe, fitting, and valve manufacturers have had a large part in the development of steam-generating equipment and have made use of standardization in one form or another for many years.

In 1921 a group, to be known as the Sectional Committee on Pipe Flanges and Fittings, was organized under the procedure of the American Standards Association. The personnel of this Committee includes sixty-three members, representing thirty organizations, and is composed of manufacturers, users, independent experts, and general interests, including Governmental departments concerned with this project. At the present time there are eight sub-committees at work on the details of this subject.

I shall illustrate the functioning of sectional committees organized under the procedure of the American Standards Association by reference to the activities of the Sectional Committee on Pipe Flanges and Fittings. I shall refer briefly and more specifically to the standardization of cast-iron flanged fittings as an example of this work. In the formulation of the series of standard fittings for 125 lb. pressure, three standards were used, namely, the A.S.M.E. standard for 125 lb. pressure, the H.P.C.N.A. standard on the same subject, and a third, which has just recently been established by the American Society for Testing Materials, No. A126–29T, which is a specification for regular gray iron and high-strength cast iron.

Shortly after the first meeting of the Sectional Committee on Pipe Flanges and Fittings, Sub-Committee No. 1 on Cast-Iron Fittings met and subdivided its personnel into four groups to which were assigned the various types of cast-iron fittings. The Sub-Committee when working on the 125-lb. standard made a careful study of the existing data relative to the standards referred to above and checked them against present manufacturers' and users' practice. This process included the adjusting of certain dimensions affecting interchangeability and the elimination of 30 per cent of the sizes formerly listed. The resulting proposal was then set in type and distributed broadly for criticism and comment. Following revision by the Sub-Committee and review by the members of the Sectional Committee, it was voted on by letter-ballot of the latter and presented to the sponsor bodies for approval and designation as an American Standard.

A similar procedure is being followed in the case of the following sub-projects: cast-iron pipe flanges and flanged fittings, all sizes for maximum working saturated pressure of 25 lb. per sq. in. (gage); cast-iron pipe flanges and flanged fittings for maximum non-shock working hydraulic pressure of 800 lb. per sq. in. (gage) at ordinary air temperatures; and ammonia fittings.

The development of the new steel flanged-fitting standards illustrates another advantage which this method of establishing national standards enjoys. The steel-flange standards were created for service conditions of 250, 400, 600, 900, and 1350 lb. pressure and 750 deg. fahr., temperature. In the upper ranges of this series the heat and power industry had little or no experience, so a considerable amount of experimental testing of proposed standard fittings was necessary. In this work Sub-Committee No. 3 had the hearty cooperation of the testing laboratories of Carnegie Institute of Technology, the Pennsylvania Railroad, and a large manufacturer of flanged material located in Pittsburgh.

Another form of cooperation of which sectional committees are able to take advantage is illustrated by the many experiences of the Committee of which I have the honor to be a member, the Sectional Committee on Pipe Flanges and Fittings. When its several sub-committees desired to include in their draft standards specifications of materials which corresponded with the dimensions and safe stresses which they had set up, requests were made to the American Society for Testing Materials for its assistance. When A.S.T.M. standards were immediately available, permission to use was promptly given. When, however, this was not the case, the A.S.T.M. assigned the task to one of its standing committees or organized a new committee for the purpose.

As soon as the A.S.A. procedure was well established, technical societies and trade associations voluntarily placed certain of their standards of long standing under its procedure. This was true of the pipe-thread standard so essential to the industry for which I am speaking. Thirty-six years before the A.S.A. was organized, Robert Briggs advocated the standardization of pipe threads in a paper read before the Institution of Civil Engineers. His recommendations became standard American practice, and eventually, under the sponsorship of the American Gas Association and The American Society of Mechanical Engineers, they were officially recognized and published by the latter. In 1919 a Sectional Committee revised and enlarged the first publication, and after approval it became the first "American Standard" approved by the A.S.A.

Until comparatively recent years, manufacturers determined the dimensions and proportions of their product independently of their competitors, and in many cases this compelled the users to return to their original source of supply for replacement material. This practice has led to the development of so-called individual or firm standards. The large users also have played this game. Standards of dimension and material have frequently been included in specifications prepared by them. This practice on the part of the producers and consumers has led to the production of uneconomical variety. The former tries to create something special to attract customers and to keep them. The latter often unnecessarily considers his requirements as special. Industry is more and more realizing that the common interests must be placed above the interests of the individual firm or group, whether it be the manufacturer or user of the product. National standardization raises the general level of quality and reduces the cost of production of an article, thus making it available to the largest possible number. National standards result in more economies than company or firm standards.

[2] Engineer of Product, The Crane Company. Mem. A.S.M.E.; Past Member, A.S.M.E. Standardization Committee; Chairman, Sub-Committee No. 1 on Cast Iron Flanges and Flanged Fittings; and Chairman Sub-Committee No. 4 on Materials and Stresses, both of the Sectional Committee on Pipe Flanges and Fittings.

Though my point of view is that of a manufacturer, I believe I can realize the benefits of national standardization to the consumer of the product. The old adage, "let the buyer beware," has long since fallen into ill-repute. The setting up of standard specifications which define precisely the properties and performance of the product, thus permitting easy reproduction and readily applied acceptance tests, lifts a load from the shoulders of the purchasing engineer and agent. He now has the assurance when purchasing a standardized product that systematic surveys have eliminated unnecessary variety and that it is well suited in design, material, and workmanship to the purpose for which it was made.

The manufacturer's concern, on the other hand, is one of production and marketing. He is keen to take advantage of standardization because it reduces his factory costs and helps in the disposal of the product. The process of developing standards must, however, be slow enough to permit him to adjust his manufacturing methods and stocks to the new conditions without great loss. The manufacturer's investment in tools and equipment must be recognized and the transition period so timed that no real hardship is thrown on him.

As valuable and necessary as standardization is, it has its limitations—or rather it must be recognized to be a continuing process. A standardized product should be the result of the best knowledge and experience at the time of its development. Tomorrow or next year it is subject to improvement as a result of advancing knowledge and experience. Those that hold this opinion concerning standardization have no fear that individual initiative will be hampered in any way by this important development in industry. In reality, since rational standardization is applied principally to certain common features or elements of a product, more attention can be given thereby to the design and construction of the special features.

It must be apparent from the foregoing that one of the essentials of successful engineering-standardization procedure is careful deliberation, and this, in conclusion, cannot be overemphasized. Under no circumstances should an attempt be made to "grind out" standards. The road of technical progress must be left free and national standardization begun at the point where individual efforts are not justified by the results to be achieved. In this way the forces and resources of industry are left free to tackle the really urgent and newer problems of industry.

I shall close by quoting Henry Ford, who has defined standardization in an apt way which seems well worthy of placing on record: "Standardization, in its true sense, is the union of all the best points of commodities with all the best points of production to the end that the best commodity may be produced in sufficient quantity and at least cost to the consumer."

The Influence of Standardization in Machine Design

BY J. B. ARMITAGE,[3] WEST ALLIS, WIS.

WHEN a machine-tool man thinks of machine design, he generally thinks only of machine design as applied to machine tools. When he inspects the delicate mechanism of a stop watch or the ponderous recoil mechanism of a 16-in. gun, he instinctively asks, "Where can I apply this mechanism to my product?" And so my treatment of the machine-design phase of standardization will be from the viewpoint of the machine-tool industry.

The machine industry is concerned with three types of standardization—first, internal or individual company standardization; second, group or national standardization; third, international standardization.

It is unfortunate but quite natural that the more standardization we have of the first type, the more difficult it is to establish standards of the second and third types, for the economies resulting from the adoption of company standards are much more apparent and of much more direct benefit to the individual company than are national standards. They are in reality competitive standards, are as much a part of the company's product as other design features, and play a large part in the success or failure of a company.

While the savings effected by internal standards go directly to the company adopting them, they are, of course, largely passed on to the consumer as better value. Keen competition assures this.

The machine-tool industry is an example of an industry in which the standardization is very largely internal standardization. Such group standards as we have are mostly standards that were originally individual company standards which have been gradually adopted by a large part of the industry. Many of these standards are good and have gained their position through merit. Others have gained their ascendency through the dominant position which the company that formulated them holds or has held in the industry.

Complaints have been made by standardization committees that there is, or has been, a great deal of inertia on the part of the executives of machine-tool companies in contributing to or helping national or group standardization. Whether this is so or not, there is a very logical reason for such a condition. Machine-tool plants are largely plants which have been in business for a great many years, established when national standards for the various details and machine elements did not exist. Each company found it necessary to establish its own standards for its machine elements, and naturally a great diversity of styles and sizes resulted. Many of these standardized elements became identified with the various companies, some having gained the position of quite universal adoption, and the company executives, of course, are very reluctant to give up any real or fancied advantages and advertising value which might accrue from the use of these standards.

These plants have on hand the tools, fixtures, etc. for the manufacture of these parts, and if the parts themselves are giving satisfaction it is perfectly natural that the plant executives will not be very enthusiastic about establishing a national standard which will give them a part perhaps different but no better, and one which will require more or less expenditure for changing of drawings, schedules, fixtures and other tools, and the obsoleting of parts which may be on hand. And so we should not be surprised if machine-tool executives do not enter wholeheartedly into our schemes for formulating national standards.

The automotive industry is perhaps our best example of an industry whose standards are largely group standards. It has been reliably estimated that the savings to the automotive industry due to their standards are equal to not less than 15 per cent of the total annual retail value of American automotive products, and to these standards, together with the benefits obtained by mass production, we can largely attribute the great value received for the dollar spent in automotive products.

Generally, the greatest economic returns are obtained from national standards by allowing one or more manufacturers to specialize on a particular element, manufacturing it in large quantities and supplying the entire industry, whose various plants would perhaps each need only a relatively small amount.

The setting up of internal or company standards rather than national standards is often the cause of much hardship.

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Examples of this are the diametrically opposed viewpoints of the machine-tool builders and the electric-motor manufacturers. The electric-motor manufacturers, of course, urge their customers to standardize on their particular make of motor, for this helps greatly in motor maintenance. On the other hand, it inflicts a great hardship on machine-tool builders. The machine-tool builder would naturally prefer to standardize on a particular make of motor and control equipment for a given machine as far as current characteristics allow, but with his various customers standardizing on the many different makes of motor, this is impossible, and the motor application must be extremely flexible to accommodate all these various shapes and sizes.

The customer's internal standardization therefore makes it necessary for the machine-tool manufacturer to increase the number and variety of motor bases, sprockets, pulleys, and other parts necessary to apply the various sizes of motors and control mechanisms to the machine. These conflicting viewpoints, of course, can only be brought into line by national standardization of the essential motor and controller dimensions. In other words, internal or company standardization is not enough, for in many cases it simply transfers the hardship from one party to another, and this condition can only be corrected by national standardization.

Simplification, or the elimination of unnecessary sizes, is an important part of standardization. It is regrettable that so many of the members of standardization committees, men who are unselfishly giving of their time, are either governed too greatly by expediency or do not thoroughly understand how best to accomplish the greatest simplification.

Much has been written about the advantages of size series in geometrical progression. It is now largely accepted by men who have given thought to this subject that, for most standardization work, particularly where a standard is being established covering a considerable range of different sizes, any given range can best be covered with the minimum number of sizes when these sizes are placed in a geometrical progression.

It is extremely difficult to get all standardization-committee members to see that $2^1/_2$ bears exactly the same relation to 2 that $^5/_8$ does to $^1/_2$, that if a $^9/_{16}$-size is not required, then neither are $1^1/_8$-, $2^1/_4$-, $4^1/_2$-, etc., sizes required.

The series of preferred numbers which is being used in Continental Europe and which has been advocated for use in this country, is not very well suited to English measurement. The rounding out of the numbers gives a haphazard progression rather than a true geometrical progression. I know that many of you are going to say, "Let us scrap the English system of measurement and use the metric system," but machine-tool designers and executives are almost unanimously in favor of English measurements, so we may expect to use English measurements at least for some little time.

Myron E. Steczynski, in an article published in the November, 1928, issue of MECHANICAL ENGINEERING, advocated what he called a "Semi-Geometric Series of Preferred Numbers for American Practice." This is a series formed by starting with unity and doubling and halving to expand the series upward or downward as desired. This gives a primary geometric series, the ratio being 2. For finer divisions each term is divided into an arithmetical series of 2, 4, 8, or 16 terms, thus giving what Mr. Steczynski is pleased to call a semi-geometric series. This article should be read by all who are interested in standardization, and certainly by all standardization-committee members. It gives a series far more logical for use with English measurements, and, I believe, even for use with metric measurements, than the European preferred-number series.

However, for most standardization work a still simpler method can be followed. It is a method which I have used in the past and which I have called a composite series. "Composite Series," however, in this case has exactly the same meaning as Mr. Steczynski's "Semi-Geometric Series." Again we have a geometrical progression with 2 as the ratio, and with an arithmetical progression between each term.

The difference between the composite and the semi-geometric series is that to construct a composite series we select as the key or base number the number of terms in the arithmetical series. If we select 5 as our base number, dividing by 2 gives $2^1/_2$ as the next lower term in the geometric progression, and filling in the five terms of the arithmetical series gives $2^1/_2$, 3, $3^1/_2$, 4, $4^1/_2$, and 5 as terms in the composite series. This is the first arithmetical series, and by dividing and doubling the series can be expanded in either direction as far as desired. Any number can be used as the base or key number, each one giving an entirely different composite series.

For some purposes it may be desirable to have this key number as high as 20 or 25, an example of a high-number series being the sizes of bar steel. If we decided that we should vary by eighths from $2^1/_2$ in. to 5 in., we should have twenty terms in the arithmetical progression and so should select 20 as our base number. This would automatically determine that stock sizes from $1^1/_4$ in. to $2^1/_2$ in. would vary by sixteenths, sizes from $^5/_8$ in. to $2^1/_4$ in. by thirty-seconds, sizes from $^5/_{16}$ in. to $^5/_8$ in. by sixty-fourths, and sizes from 5 in. to 10 in. by quarters, from 10 in. to 20 in. by halves, and from 20 in. to 40 in. by even inches.

Of course, it should always be borne in mind that for economic reasons it is always desirable that the number of sizes covering a given range be kept as low as possible, and for this reason the lowest base number that will adequately fulfil the requirements of industry should be the one selected for any particular standardization work.

Changes due to industrial progress are taking place continually. As a result of research, investigation, and development's giving us new materials and pointing out new methods and processes, the designs of our machines are continually changing and must continue to change. Plain bearings give way to anti-friction bearings, shafts with loose keys are replaced by shafts with integral keys, spur gears are changed to helical and herringbone gears, but we cannot say these changes are final nor do we expect them to be. All manufacturers make these changes as progress dictates, although the change is extended over a considerable period, but once a part is standardized, too many of us are prone to expect that that particular detail is fixed for all time and will never be changed.

This viewpoint obviously is erroneous. We know that the engineering progress which makes it necessary to change other machine parts will also make it necessary to change parts which have been standardized, and standards to be successful must keep pace with the progress of industry. Changes that truly represent progress are as inexorable as the tides, and standards established today to fit today's needs may be entirely obsolete in a few years, and if so, we should not hesitate to change or discard them or to formulate new standards. The fact that this is so should not make us hesitate to establish new standards, for the cost of changing a standard because it has become obsolete is not nearly so great, nor will it cause so much inconvenience, as the changes due to this same industrial progress upon a multiplicity of designs.

Whether all manufacturers have standardized on a particular design which has become obsolete through progress or whether each one is using a different design which has now become obsolete through this same progress, the design change will ultimately have to be made by each manufacturer, either collectively by adopting a new standard or individually by each manufacturer.

Let me illustrate: Three years ago, Brown & Sharpe tapers were in use almost universally in milling-machine spindle ends and for arbors, end mills, and other milling-machine tools. When first adopted, the Brown & Sharpe tapers of 1/2 inch per foot were probably as nearly perfectly adapted for this use as could be desired. However, the development of the milling machine into the high-power, heavy-duty machine of today made the need for a non-sticking taper apparent. So the engineers of the leading milling-machine companies formed a committee under the sponsorship of the N.M.T.B.A. Extensive experiments were made with new designs of spindle ends with non-sticking tapers, the new nationalized spindle end for milling machine was announced, and for this use the Brown & Sharpe taper became obsolete. Here is an ideal example of the benefits of group research and standardization. It is obvious that all the milling-machine manufacturers sooner or later would have found it necessary to abandon the Brown & Sharpe tapers in favor of a non-sticking taper. It is not to be expected, however, that without standardization all manufacturers would have adopted the same taper per foot and the same taper diameters. Each manufacturer would have made some change at as great or a greater expense than the individual cost of adopting the standardized spindle end, but industry would once again have had inflicted upon it the deplorable condition of each manufacturer's machine requiring special cutters and arbors. The thought should be kept in mind that it costs considerably less to change a part which has been standardized and is used by the whole industry than it does for each individual to have his own design and make his own changes as progress dictates.

Much of the resistance to standardization and the lack of interest found by standardization committees is due to the lack of progressiveness of the standards proposed. To be successful, standards must be progressive and constructive.

It should be remembered that engineering standards cannot be forced upon an industry. The formulation involves a great deal of expense and personal sacrifice, and this expense and sacrifice is justified only when the resulting standards meet the general approval of the industry and are freely adopted. The men who give their time for the formulation of standards have a right to hope, and perhaps even to expect, that the standards evolved will ultimately come into quite universal use, but these hopes will only be realized if the standard has merit, if the necessary information is put in usable, easily understandable form, and, most important of all, made readily available whenever needed.

As engineers it is our business to formulate live, progressive standards—standards that represent the best practices in the industry at the time they are evolved—standards that represent practices at least equal to the practice of the best individual company in the industry, and often, by combining the best from the various practices of all the companies, the standard can and should represent a practice that is better than that of any individual company. Whenever possible the standard should be better than present practice. It should be the culmination of our past experience and the result of research up to the present time, and should be our idea of the best practice of tomorrow. Only such standards should be evolved by engineers, and only such standards justify the enormous expenditure of time and money necessary for their formulation.

And so the present needs of our standardization committees are for men with knowledge of what has been done in the past, men with vision who can extract the best from research, but most of all, courageous men who are not afraid to adopt progressive standards, standards which are worthy of being used as tomorrow's practice rather than standards based on the practice of yesterday.

Influence of Standardization on Quantity Production

By D. B. CHARTERS,[4] EAST PITTSBURGH, PA.

THE World War probably gave standardization its greatest impetus, and the period of depression which followed almost compelled manufacturers to apply the lessons learned during that conflict. Efforts at standardization by individual manufacturers are being unified through the activities of such bodies as the American Standards Association, the A.I.E.E., A.S.M.E., and the S.A.E. However, the manufacturers must extend themselves to set up standards, even within the national standards so far established. For instance, while the Westinghouse Company can fill requirements as to rating, temperature rise, overload capacity, voltage, etc., as determined by the accepted standards, it has its own problems of simplifying and standardizing its apparatus for the shop.

Particular effort has been made to accomplish results on the slow-speed synchronous-motor line, known as the "HR" and the line of direct-current apparatus known as the "QS" line. The first attempt was made on the "HR" line and has been in process of development for several years. It might be well to state that when the word "standard" is used in the following paragraphs in regard to speeds and voltages, it is the customary or accepted practice that is meant. On this basis there are 18 standard synchronous-motor speeds from 100 to 540 r.p.m., 24 standard horsepower ratings from 25 to 1500 hp., 6 armature voltages from 220 to 6600, two field voltages 125 and 250, and some two-phase but mostly three-phase machines. There are some parts, particularly coils, which must vary with the electrical characteristic desired. Consequently efforts to standardize were confined to the mechanical parts upon which the greater part of the manufacturing time is expended. The frame diameters have been confined to 5 sizes, stator punchings to about 18 items, while there are about 14 sizes of pole punchings, and sizes of rims for the rotating part are 10 in number. From this comparatively small number of parts it is possible to make all sizes of synchronous machines within the limits previously mentioned.

The principal parts that change with the ratings are coils, frame spacers and bolts, and the frame feet. The steel-plate hubs for the rotor are made large enough to accommodate the largest bore used for the particular size; brush holders, collector rings, and brush rigging are standard for each frame size. Spacers are cut from standard steel shapes, while the coils are wound on shuttles and pulled to shape on an adjustable pulling machine. There are approximately 600 ratings which the company can furnish from the following small number of major parts: 5 frame sizes, 10 spider rims, 18 compound dies for stator punchings, and 14 dies for pole punchings. This condition—that of having a minimum number of major parts—makes it possible for the Production Department to bring these parts through in reasonable quantities and carry them in stock, so that when an order reaches the shop, shipment can be governed largely by the time necessary to make the small variable items, such as coils, frame spacers, feet, etc., and to effect the general assembly.

The production supervisor on this particular line of apparatus states that delivery time has been reduced 40 per cent as compared with the old cast line, and this fact, together with the lessened cost of construction, must eventually be of benefit to the customer.

The use of a certain number of constant or standard parts has facilitated the work in the Engineering Department, because

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it is possible to prepare in advance standard drawing lists covering a given set of parts required for any particular machine. In handling each individual order it is only necessary then to make simple coil sketches for the field and armature windings, which, together with the previously mentioned standard-part list, comprise all the engineering information necessary for manufacture.

A valuable feature of this standard-part plan is the system of records which has been built up about it. These records show all the standard parts, as well as the particular items carried in stock. With these records available it is possible to make special combinations of standard parts for highly specialized machines. In case it becomes necessary to make any changes in the standard parts for the purpose of cost reduction or improvement in design, this system of records makes it easily possible. This is an important feature of the standard-part plan, because usually a change in a standard part requires changes in the standard-dimension leaflets for all district offices, and changes in the standard drawings, shop tools, permanent manufacturing information, and arrangements for the disposition of superseded parts. It can be seen from this brief statement that providing for all factors in an orderly and complete manner is of the utmost importance.

Another principle that has been followed is the designing of parts intended for a certain use similar in appearance and construction throughout the line. By making the fixtures adjustable each fixture as a rule will serve for the whole line. Some examples of what can be accomplished by means of standardized parts toward the elimination of unnecessary sizes and parts which must be carried in stock are listed below:

1 Any frame in one line can be made from some one of 18 sections of steel slabs carried in stock.

2 Four bar sections only are necessary to make all brush-holder brackets.

3 Spider arms for rotating members use but nine bar sections.

4 Four sizes of carbon-brush holders cover the requirements of the entire line.

5 Five sizes of H-beams are carried in stock, from which are made all sizes of bedplates.

The standard-part plan, which greatly simplified design, manufacture, and production scheduling, has other advantages of minor importance but which are of sufficient moment to be worthy of consideration.

6 The drafting room can prepare a master tracing for each part and use lithoprints for the working drawings.

(*a*) But one master tracing for frames.

(*b*) Four master drawings for all B.H. brackets.

7 The average development charge per order has decreased about 66 per cent. This charge includes engineering, drafting, and shop tools. It is expected that with further experience the overall decrease will be about 85 per cent for the new line as compared to the old.

8 The time required to get complete engineering information into the shop has been reduced approximately 50 per cent.

Summing up briefly what has been accomplished by standardizing the design of d.c. machinery:

1 Corresponding parts for any size of machine are identical in design, varying only in size. For instance, all frames on this line are welded on one adjustable fixture which locates the parting flanges, frame feet, and braces.

2 By the use of a comparatively small number of standard steel shapes, plates, and slabs which can be carried in stock, material is always available for fabrication. This relieves the Production Department of the burden of ordering special material and contending with delayed shipments, imperfect castings, etc.

3 Design problems on the mechanical parts of new ratings resolve themselves into the simple matter of placing dimensions on a standard drawing, where all questions as to design and construction have already been decided.

4 Complete information consists largely of standard drawings and the small number of variable components, many of which are made up in turn by standard parts or units.

5 Since corresponding parts for various sizes are similar in shape and construction, costs can be predicted very accurately.

The foregoing very briefly describes a part of one firm's program to standardize some of the apparatus which heretofore has been considered almost entirely as special machinery, with all its resultant disadvantages as to engineering and production. In closing, it might also be well to mention the work of the Standards Engineering Department. This department was created:

a To evolve and compile standard practices and methods in making drawings, machine designs, manufacturing allowances, tolerances, etc., through individual investigation or upon recommendations of standards sub-committees

b To prepare "Standards Tabulated Drawings" of certain interdepartmental parts and in this way to avoid duplications and near duplication of parts

c To restrict the number of sizes of materials carried in stock and to advertise same to interested manufacturing sections

d To prepare uniform apparatus identification plates.

These activities are summarized in the Shop Standards Book under material sizes, tolerances, patterns, tools, etc.

Some concrete results of this standardization activity are tabulated below.

Items	Number before standardization	Number afterward
Copper wire, bare and insulated	220	53
Copper sheet	94	52
Brass bar stock	216	104
Cable	350	180
Brass tubing	206	90
Thumb nuts	50	3
Copper and brass studs	1760	662
Punched vent fingers	747	74
Carbons	525	220
Counterbores, shanks, cutters	1861	200
Machine bolts	179	148
Slate	336	70
Oil rings	72	44

The New Cast Iron

THE term "cast iron" has been generally understood to mean a material having a tensile strength of 15,000 to 20,000 lb. per sq. in.; but this idea is no longer correct, for there are perhaps as many kinds of cast irons as of steels, and these irons cover a wide range of physical properties. Many foundries now are producing reliable gray-iron castings having tensile strengths ranging from 30,000 to 60,000 lb. per sq. in., and with very much higher increases proportionately in the impact strength. These important changes in the physical properties are the result of excellent cooperation between the metallurgist and the foundryman, and they have been obtained by the proper use, either singly or in varying combinations, of such metals as chromium nickel, molybdenum, and vanadium. The success achieved in producing these modern castings is the result of working primarily to obtain quality, so that the increase in reliability and strength much more than offsets the increase in cost. This notable development is of importance to practically all manufacturers of mechanical apparatus.—*Machinery*, February, 1930, p. 442.

Analysis of Engineer Registration Laws of the United States

Compiled by the American Engineering Council

THE American Engineering Council represents twenty-four national, state, and local engineering organizations which have a constituent membership of 58,000 professional engineers. Ever since its organization in 1920 it has endeavored to keep currently informed on the question of engineer registration laws because numerous inquiries are continually being received concerning the question.

These inquiries have become so varied and the material so voluminous and presented in so many different state laws, that a composite and brief analysis of all such existing laws has been made.

The analysis herewith presented is a thorough and impartial tabular analysis of the laws of twenty-five states and the territory of Hawaii. In addition to those listed, Texas has a registration law for land surveyors only; Georgia and the District of Columbia have registration laws for architects only; and the Philippines and Porto Rico have registration laws for architects and engineers.

COMPOSITION OF EXAMINING BOARD

State	Civil	Electrical	Mechanical	Mining	Architect	Total
Arizona	6 optional (1 professor at state university)					7
Arkansas	5 professional engineers					5
California	3					3
Colorado	4 optional (1 state engineer)					5
Florida	3		1	1 E.M. or 1 E.E.		5
Hawaii	3 optional		2 surveyors		2	7
Idaho	3					3
Illinois	Under Department of Education					
Indiana	2 professional, 1 optional					5
Iowa	2 surveyors					5
Louisiana	All professional engineers					
Michigan	5[1] or five surveyors selected from a list submitted by Lousiana Engineering Society					5
Minnesota	5 optional				2	7
Mississippi	1		1	1 surveyor	3	7
New Jersey	5[3] optional					5
New Mexico	5 optional					5
New York	3 surveyors, 1 of whom is state engineer					3
North Carolina	5 optional					5
Oregon	1 from the Faculty of the North Carolina State College of Agriculture, 1 from the Engineering Faculty, Univ. of North Carolina, 3 optional; not more than 3 to be from the same branch of engineering					5
Pennsylvania	2	1	2	2	2[7]	9
South Carolina	5 optional					5
South Dakota	3	1 E.E. or 1 E.M.	1			5
Tennessee	3[3] optional				2	5
Virginia	3[4] optional				3	6
West Virginia[6]	3[5] optional, professional engrs., surveyors				3 surveyors	9
Wyoming	optional 5 professional engrs.					5
	State engineer, 1 professional engr. and 1 surv.					3

[1] If Lousiana Society fails to submit list then Governor may select appointees at his own discretion.
[2] Future boards must have two teachers.
[3] Surveyors. One of these must also be a land surveyor.
[4] In determining the qualifications of applicants, only a majority of board members who are of the applicant's profession, is required.
[5] Same as Tennessee.
[6] Board members required to belong to engineering society. Membership in founder society may be one of qualifications for registration.
[7] Hydraulic engineer.

APPOINTMENT AND COMPENSATION OF EXAMINING BOARD

State	Method of appointment	Compensation of members	Compensation of secretary	Length of service of board members	Members necessary to carry vote	Number of registrants as of 1927
Arizona	6 by governor + 1 professor	Trav. exp.	None	3 yr.	4 (a)	267
Arkansas	By governor	Trav. exp.	Fixed by Board	4 yr.	Majority	219
California	By governor	$25 per day (b)	$3600 per year	4 yr.	Majority	1600
Colorado	4 by governor + 1 state engr.	Trav. exp.	None	4 yr.	3	500
Florida	By governor	Trav. exp.	None	4 yr.	Majority	814
Hawaii	By governor	.....	.....	...	....	180
Idaho	By Dept. Law Enforcement	$10 per day. Tr. exp.	One of Board	At will of dept.	Majority	300
Illinois	.....	.....	.....	...	....	840
Indiana	By governor	$10 per day. Tr. exp.	Fixed by Board	3 yr.	3	909
Iowa	By governor	$10 per day. Tr. exp.	One of Board	4 yr.	3	1310
Louisiana	By governor	$10 per day. Tr. exp.	One of Board	6 yr.	3	425
Michigan	By governor	Trav. exp.	.....	7 yr.	5.7	1426
Minnesota	By governor	$10 per day. Tr. exp.	One of Board	4 yr.	4 (c)	603
Mississippi	By gov. subject to approval of Congress	Trav. exp.	One of Board	4 yr.	3	...
New Jersey	By governor	Trav. exp.	Fixed by Board	5 yr.	3	1836
New Mexico	By governor	Trav. exp.	State engr.	2 yr.	....	250
New York	By regents	Fixed by regents	None	5 yr.	3	8500
North Carolina	By governor	$10 per day. Tr. exp.	One of Board	4 yr.	3	752
Oregon	By governor	Trav. exp.	$1200 yr.	6 yr.	5	1682
Pennsylvania	By governor	$15 per day. Tr. exp.	None	5 yr.	Majority	3284
South Carolina	By governor	$10 per day. Tr. exp.	One of Board	4 yr.	Majority	283
South Dakota	By governor	Trav. exp.	One of Board	4 yr.	Majority	311 (d)
Tennessee	By governor	Trav. exp.	None	6 yr.	4 (e)	300
Virginia	By governor	$10 per day	Fixed by Board	7 yr.	5	975
West Virginia	By governor	$10 per day	Fixed by Board	4 yr.	3	239
Wyoming	By governor	$10 per day	State engr.	4 yr.	2	152

(a) One must be an architect and two engineers.
(b) For time actually spent to and from and in attendance of meetings of the board. This also applies to other states which pay by the day.
(c) Two architects and two engineers.
(d) Number of registrants as of July 1, 1928.
(e) Two shall be architects and two engineers.

SCHEDULE OF FEES

State	Date of enactment	Amendments	Compulsory	Professional	Examination fee: Architect	Examination fee: Engineer	Examination fee: Surveyor	Registration fee: Engineer	Total fee	Renewal fee: Engineer	Renewal fee: Surveyor	Renewal fee: When payable	Reciprocal fee: Engineer	Reciprocal fee: Surveyor	Authority and conditions for granting reciprocal agreements.
Arizona	1921	1923–29	Yes	Yes (*e*)	Yes	$15 (*f*)	$10	...	$25	$15	...	Every year	$10	...	At discretion of board.
Arkansas	1925	.....	Yes	Yes	...	$15	...	$10	Sur $10 Eng. $15	$5	$5	Every year	$1 (*f*)	$1	Standard must be satisfactory to board.
California	1891	1929	Yes	(*d*)	...	$15	...	$10	$25	$5	...	Every year	$10	...	Standards not lower than provided by this act.
Colorado	1919	1927	Yes	Yes (*e*)	(*c*)	$15	$15	...	$15	$5	$5	Every year	...	...	Standard must be satisfactory to board.
Florida	1918	1925	Yes	Yes*	(*c*)	$15	...	$10	$25	$5	...	Every year	$25	...	Standard not lower than provided in this act.
Hawaii	1923	..	Yes	Yes (*e*)	Yes	$15 (*f*)	$15	...	$15	$5 (*f*)	$5	.....	$15 (*f*)	$15	
Idaho	1919	..	Yes	(*d*)*	...	$25	...	...	$25	$2	...	Every year	...	...	Discretion of board.
Illinois	1916	..	Yes	(*b*)	...	$15	...	$5	$20	$1	...	Every year	$15	...	1—Applicant must be 21 years old. 2—Standard of other state law must be equal to that of Illinois.
Indiana	1921	1923–27	Yes	Yes (*e*)	...	$25	$25	*	$25	$5	$5	Every year	$25	$25	Standard must be satisfactory to board.
Iowa	1919	1924–27	Yes	Yes (*e*)	...	$15	$15	$10 (*e*)	$25	$2	$2	Every year	$10	$10	Discretion of board.
Louisiana	1908	1914–20	Yes	(*d*)(*e*)	(*c*)	$25	$25	...	$25	$3	$1	Every year	$15	$15	Satisfactory to board. Applicant must be in good standing in home state.
Michigan	1915	1919	Yes	Yes (*e*)*	Yes	$5 (*f*)	$5	$15 (*f*)(*e*)	$20	$5 (*f*)	$5	Every 5 yr.	None stated		Standard to be as high as Michigan's.
Minnesota	1921	..	(*a*)	Yes (*e*)	Yes	$25 (*f*)	$10	...	Sur. $10 Eng. $25	$5 (*f*)	$2	Every year	$25 (*f*)	$10	Standard must be equal to that of Minnesota.
Mississippi	1920	..	Yes	Yes	...	$25	...	...	$25	$10	...	Every year	$25	...	Standard must be satisfactory to board.
New Jersey	1922	1923–26–27	Yes	Yes (*e*)	(*c*)	$25	$25	...	$25	$1	$1	Every year	$25	$25	Standard not lower than New Jersey statute.
New Mexico	1917	..	Yes	(*e*)	...	...	$5	...	$5	...	...	.....	...	...	Standard not lower than that of New York.
New York	1920	1927	Yes	Yes (*e*)	...	$25	$25	...	$25	$1	$1	Every year	$25	$25	Also provided a reciprocal agreement has been entered into with other state.
North Carolina	1921	..	Yes	Yes (*e*)	(*c*)	$25	$10	*	$25	$5	$5	Every year	$25	$10	Same as New York.
Oregon	1919	..	Yes	Yes*	(*c*)	$10	...	$5	$25	$3	...	Every year	$15	...	Optional with board.
Pennsylvania	1921	1927	Yes	Yes (*e*)*	(*c*)	$10	$10	$10 (*e*)	$10	$1	$1	Every year	$20	$20	Standard not lower than provisions of this act.
South Carolina	1922	1928	Yes	Yes (*e*)	(*c*)	$15	$15	$10 (*e*)	$25	$5	$3	Every year	$25	$25	Same as Pennsylvania.
South Dakota	1925	..	Yes	Yes (*e*)	Yes	$20 (*f*)	$10	$5 (*e*) (*f*)	Sur. $15 Eng. $25	$5	$5	Every year	$10 (*f*)	$10	Standard must be satisfactory to board.
Tennessee	1921	1925	Yes	Yes	Yes	$10 (*f*)	...	$15 (*f*)	$25	$5 (*f*)	...	Every year	$25 (*f*)	...	Standard must be satisfactory to board.
Virginia	1920	1925	Yes	Yes (*e*)	Yes	$25 (*f*)	$25	*	$25	$5 (*f*)	$2.50	Every year	$25 (*f*)	$25	Standard must be satisfactory to board.
West Virginia	1921	1923	(*a*)	Yes (*b*)	...	$20	...	*	$20	$10	...	Every year	...	...	Standard must be satisfactory to board.
Wyoming	1907	1925	Yes	Yes (*e*)	...	$15	$15	...	$15	$5	$5	Every 2 yr.	$10	$10	Standard must be satisfactory to board.

(*a*) Optional.
(*b*) Structural Engineer.
(*c*) Have separate law.
(*d*) Civil Engineer.
(*e*) Surveyor.
(*f*) Architect.
* See note for state below.

Notes

Arizona. 1—Assayer required to register. 2—Registered engineer required on all public works over $5000. 3—Registration fee returned if applicant fails.

Florida. *Includes all professional engineers except military. 1—Registered engineer required on all public work over $1000.

Hawaii. 1—Membership in founder soc. necessary for registration. 2—Registered engr. required on all public works over $15,000.

Idaho. Civil engineer within the meaning of the statute is any branch of the profession of engineering except mining, metallurgy, and military. There is a separate law for surveyors.

Indiana. *Sixty-six (66) per cent of application fee is returned if applicant fails.

Iowa. No two board members may be from the same branch of the profession.

Michigan. *Includes all professional engineers. Registered engineers required on all public work over $2000.

Minnesota. 1—Registration fee is returned if applicant fails. 2—For determining the qualifications of architects, only architect members of the board may constitute a majority. Also applies to engineers and surveyors.

Mississippi. Registered engineers required on all public work over $5000.

New Jersey. 1—If applicant is refused, his fee is returned. 2—Registered engineer required on all public works over $2000. 3—Board must be approved by the Senate.

North Carolina. Regular fee returned if applicant is refused. Law automatically registers World War student veterans and members of founder societies.

Oregon. *Profession of engineering in any of its branches except military.

Pennsylvania. *The profession of engineering in any of its branches. 1—Original act declared unconstitutional. 2—No renewal permitted without examination after 12 months' failure to renew.

Tennessee. *Half of fee returned if applicant is refused. 1—A corporation may engage in the practice of engineering provided one of the principals in responsible charge is registered as provided.

Virginia. *$5 is returned if applicant is refused.

West Virginia. *If applicant is refused his registration fee is returned.

EXEMPTIONS

State	
Arkansas	1—Operatives. 2—Employees. 3—30-day reciprocal. 4—Associates. 5—Government employees.
Arizona	1—Operatives. 2—Employees. 3—90-day reciprocal. 4—Associates. 5—Non-residents.
California	1—Government employees. 2—Employee of registered civil engineer.
Colorado	1—Government employees. 2—Non-residents, 90-day reciprocal. 3—Associates. 4—Employees. 5—State and Government employees.
Florida	1—Employee of U. S. Government. 2—Employee of registered engineer. 3—Non-residents. 4—Architects.
Hawaii	1—Employees. 2—Government employees.
Idaho	1—Government employees. 2—Employees of registered engineer. 3—Non-residents.
Illinois	1—Employees of registered engineer. 2—Any person when building or constructing a structure for himself.
Indiana	1—Non-residents. 2—The same, provided such person has filed application for license. 3—Employee of registered engineer. 4—Employee of Government or state.
Iowa	1—Employees. 2—Government employees. 3—Non-residents who have applied for certificate.
Louisiana	1—Government employees.
Michigan	1—Non-residents. 2—Employee of registered engineer. 3—Employees of railroad and other interstate corporations.
Minnesota	1—Non-residents. 2—Employees. 3—Government employees.
Mississippi	1—Operatives. 2—Employees. 3—Non-residents. 4—Government employees.
New Jersey	1—Employees. 2—Non-residents. 3—Government employees.
New Mexico	1—Government employees.
New York	1—Non-resident having no place of business in state. 2—Same, when such practice does not cover more than 30 days. 3—Same, provided he has filed application for license and paid the fee. 4—Employees of registered engineer. 5—Employees of U. S. Government or state.
North Carolina	1—Non-resident. 2—Non-resident qualified to practice in his own state when practice does not aggregate more than 30 days. 3—Employee of registered engineer. 4—U. S. Government employee.
Oregon	1—Government employees. 2—Architect practicing architecture. 3—Employees of registered engineer. 4—Non-residents qualified to practice in another state, not having place of business in Oregon. 5—Non-residents of recent arrival who have applied for license.
Pennsylvania	1—Resident who has filed application for registration, till Board acts upon such application. 2—Non-resident qualified to practice in his own state. 3—Employees of registered engineer or employees of an engineer coming under exemptions 1 and 2 above. 4—Government employee. 5—Employees of public service company in Pennsylvania.
South Carolina	1—Non-residents. 2—Employees. 3—Government employees.
South Dakota	1—Military engineer. 2—U. S. Government and state employees. 3—Employees. 4—In 1 and 3 the engineer or architect is not allowed to use the appelation "Professional Engineer" or "Professional Architect."
Tennessee	1—Non-residents who have no established place of business in state. 2—Same, who are not applying for certificate. 3—Employee of registered engineer. 4—Government and State employees.
Virginia	1—Non-residents. 2—Employees. 3—Employees of U. S. Government or state. 4—Practice of professional engineering by certified architect or surveying by certified engineer, provided the person uses only the titles which his certificate authorizes.
West Virginia	1—Non-residents not established. 2—Same, recently arrived provided he shall have filed application for registration. 3—Employees of registered engineer. 4—Employees of U. S. Government or state. 5—Any engineer who shall not represent himself as, or use the title of, "Registered Professional Engineer," unless such person is qualified under this act.
Wyoming	1—Government employees. 2—Non-residents. 3—Employees. 4—Contracts existing April 1, 1925.

CERTIFICATES WITHOUT EXAMINATION ("GRANDFATHER" CLAUSES)

State	Age	Length of Residence	Length and kind of experience
Arizona	25	...	Engaged in architectural or engineering work for at least six years, or three years for surveyors and assayers.
Arkansas	21	1 year	Any time before January, 1926, a person who shows that he has been practicing for one year prior to act is granted a certificate without examination.
California	25	1 year	Has practiced civil engineering for at least six years, and has had responsible charge of engineering work for at least one year.
Colorado	25	...	Engaged in active engineering work for seven years.

CERTIFICATES WITHOUT EXAMINATION ("GRANDFATHER" CLAUSES)—*Continued*

State	Age	Length of Residence	Length and kind of experience
Florida	..	1 year	Practiced professional engineering for 10 years and who has had charge of engineering work as principal for two years.
Hawaii	..	...	.....
Idaho	21	1 year	Must take an oath to support Constitution of United States and State. Six years' active engagement in engineering work.
Illinois	..	...	If he has practiced structural engineering not less than six years, two of which he has been in responsible charge of structural-engineering work as a principal he is qualified to receive a license.
Indiana	..	...	At any time within one year after this act goes into effect, any person who submits evidence that he is of good character and has been a resident of Indiana for two years, and that when this act went into effect he was practicing professional engineering, the Board may issue him a license.
Iowa	25	...	Graduate of a recognized school of engineering, two years of practice, preceding the practice of this act.
Louisiana	..	None	.....
Michigan	..	...	Any person who has three years' experience as a principal in architecture, engineering, or surveying prior to 1915, and also World War veteran engaged as a principal in architecture or surveying, shall be given a certificate on proof that he was so engaged.
Minnesota	25	...	Prior to act residing in state. Six or more years of engineering work or four years of surveying.
Mississippi	21	...	Active practice of engineering for six years, one of which shall have been in responsible charge of engineering work.
New Jersey	21	...	Six or more years of engineering work or four or more years of surveying.
New Mexico	..	...	Lived in state prior to January 1, 1917, making application within six months after this act and had practiced prior to said date.
New York	21	...	Six or more years of engineering work (four for surveying), one of which shall have been in responsible charge of work.
North Carolina	..	...	Five or more years of active engagement in engineering or three years in surveying, provided application is made within twelve months after ratification of this act.
Oregon	..	...	A certificate will be granted to any engineer who shall satisfy the Board that he is of good character, that he has practiced engineering for at least six years, and has charge of engineering work as a principal or assistant for two years.
Pennsylvania	..	...	Ten or more years of active practice in engineering work. For surveyors, six or more years of active practice in surveying work.
South Carolina	Sur. 21 Eng. 21	1 year	Has been in practice five years prior to date thereof, during which time he has had charge of engineering work as principal.
South Dakota	21	1 year	Has practiced for five years preceding application, one of which he has been principal or assistant in some engineering work.
Tennessee	..	1 year	Has been in responsible charge of engineering work for two years prior to this act.
Virginia	..	...	Any person shall be granted a certificate without examination who shall satisfy the Board that he has been engaged in practice of professional engineering or architecture for not less than six years or surveying for not less than one year before this act takes effect.
West Virginia	21	...	Ten or more years of active engagement in engineering, membership in a reputable engineering society.
Wyoming	..	...	License granted to those holding license in 1920 under old law at discretion of Board.

REVOCATION OF LICENSE

State	Reasons for revoking license	Prosecutor	Judge
Arkansas	1—Fraud or deceit in obtaining license. 2—Gross negligence. 3—Incompetency.	Any one	Board
Arizona	Same as Arkansas	Any one	Board
California	Same	Any one	Board
Colorado	Same	Any one	Board
Florida	1—Fraud or deceit in getting a certificate. 2—Conviction of a crime.	Any one	Board (not less than 3)
Hawaii	.....	.....	.....
Idaho	Same and for conviction of a felony	Any one	Department
Illinois	Same and recklessness in construction of buildings or structures	Any one	Dept. of Registration and Education
Indiana	Same	Any one	Board (4 to convict)
Iowa	Same, four-fifths vote of board necessary for revocation	Any one	Board
Lousiana	When licensee has been convicted of immoral conduct before Common Court	None stated	None stated
Michigan	1—Negligence. 2—Dishonest practice. 3—Conviction for violation of this act. 4—Deceit in obtaining license.	Any one	Board (⅘ths to convict)
Mississippi	1—Fraud or deceit in obtaining certificate. 2—Gross negligence. 3—Misconduct.	Any one	Board
Minnesota	Same as Mississippi	Any one	Board
New Jersey	Same	Any one	Board
New Mexico	1—Incompetence. 2—Negligence. 3—Dishonesty.	Not stated	
New York	Same	Not stated	
North Carolina	Same	Any one	Board (unanimous vote necessary)
Oregon	1—Fraud. 2—Deceit. 3—Conviction of a crime	Any one or Board	Board (not less than 3)
Pennsylvania	Same. The vote of three or more members will be sufficient to revoke.	Any one	Board
South Carolina	1—Fraud. 2—Deceit in obtaining certificate. 3—Incompetency	Any one	Board
South Dakota	Same	Any one	Board
Tennessee	Same	Any one	Board
Virginia	Same	Any one	Board
West Virginia	Same	Any one	Board
Wyoming	Same	Any one	Board

METHOD OF LITIGATION

State		Penalties Max.	Penalties Min.
Arkansas	Misdemeanor punishable by state	$200	$10
Arizona	Misdemeanor punishable by state	$300 6 mos.	6 mos.
California	Misdemeanor punishable by state	$500 3 mos.	$100
Colorado	Misdemeanor punishable by state	$500 3 mos.	$100
Florida	Misdemeanor punishable by state	Not stated	
Hawaii	.....	$500 1 year	1 year suspended
Idaho	Misdemeanor. Any person giving false or forged evidence in his application or falsely impersonating another practioner is guilty of felony	Not stated	
Illinois	Misdemeanor punishable by state	$200	$25
Indiana	Misdemeanor punishable by state	$500 3 mos.	$100
Iowa	Misdemeanor punishable by state	$500 3 mos.	$100
Louisiana	Misdemeanor punishable by state	$500 90 days	$100 30 days
Michigan	Misdemeanor punishable by state	$500	(a)
Minnesota	Misdemeanor punishable by state	$500 3 mos.	$50
Mississippi	Misdemeanor punishable by state	$500 3 mos.	$100
New Jersey	Misdemeanor punishable by state	$500 3 mos.	$100
New Mexico	Misdemeanor punishable by state	$100 60 days	60 days
New York	Misdemeanor punishable by state	$500 3 mos.	$100
North Carolina	Misdemeanor punishable by state	$100 3 mos.	$100
Oregon	Misdemeanor punishable by state	$500 6 mos.	$25

METHOD OF LITIGATION—*Continued*

State		Penalties Max.	Penalties Min.
Pennsylvania	Misdemeanor. After revocation registrant may appeal the case to Court of Common Pleas of Dauphin County. This is final.	$500 3 mos.	$100
South Carolina	Misdemeanor punishable by state	$500 3 mos.	3 mos.
South Dakota	Misdemeanor punishable by state	$500 (b) 3 mos.	3 mos.
Tennessee	Misdemeanor punishable by state	$500 3 mos.	$100 (c)
Virginia	Misdemeanor punishable by state	$500	$100
West Virginia	Misdemeanor punishable by state	$500 3 mos.	$100 or 3 mos.
Wyoming	County and prosecuting attorney of the county will act as committee	$500 3 mos.	$100 or 3 mos.

(a) For a second offense the maximum fine is $1000 and 1 year; the minimum, $500.

(b) For second or subsequent offenses the maximum fine will be $1000 and three months.

(c) This penalty is for using the certificate of another. For violation by practicing, the fine is not less than $10 nor more than $50 for each offense, each day constituting a separate offense.

EXPERIENCE

State	Allowance for degree	Allowance for practical experience	Total	Age	Residence
Arizona	Sur. 2 yr. Eng. 4 yr.	1 year 2 years	3 years 6 years	25 years	U. S. citizen
Arkansas	2 years	2 years	4 years	21 years	U. S. citizen
California	4 years	2 years	6 years	25 years	.....
Colorado	4 years	3 years	7 years	25 years	.....
Florida	3 years *or*	3 years	3 years	21 years	.....
Hawaii	4 years	2 years	6 years	.....	.....
Idaho	4 years *or*	6 years	4 or 6 yr.	21 years	.....
Illinois	4 years	2 years	6 years	21 years	.....
Indiana	4 years	2 years	6 years	25 years	U. S. citizen
Iowa	4 years	2 years	6 years	25 years	.....
Louisiana	4 years	....	4 years	21 years	.....
Michigan	4 years	2 years	6 years	21 years	U. S. citizen
Minnesota	Sur. 2 yr. Eng. 4 yr.	2 years 2 years	4 years 6 years	Over 25 years	U. S. citizen
Mississippi	4 years	1 year	5 years	21 years	U. S. citizen
New Jersey	Sur. 2 yr. Eng. 2 yr.	2 years 4 years	4 years 6 years	21 years	U. S. citizen
New Mexico	4 years *or*[1]	....	.....	.....	.....
New York	Sur. 2 yr. Eng. 2 yr.	3 years 4 years	5 years 6 years	21 years	U. S. citizen
North Carolina	4 years	1 year	Sur. 3 yr. Eng. 5 yr.	21 years	U. S. citizen
Oregon	4 years	2 years	6 years	21 years	.....
Pennsylvania	Sur. 4 yr. Eng. 4 yr.	1 year 2 years	5 years 6 years	21 years	U. S. citizen
South Carolina	4 years *or*	4 years	4 years	More than 21 years	U. S. citizen
South Dakota	4 years	2 years	6 years	More than 21 years	U. S. citizen
Tennessee	4 years *or*	4 years	4 years	.....	U. S. citizen
Virginia	4 years *or*	4 years	4 years	21 years	U. S. citizen
West Virginia	4 years	2 years	6 years	21 years	U. S. citizen
Wyoming	4 years	4 years	8 years	25 years	U. S. citizen

[1] Membership in any recognized engineering society or two certificates signed by three licensed surveyors that such person is competent to practice surveying.

The character of the applicant must be satisfactory to examining board in every state having a law.

The type of examination is optional with the board in all states except Louisiana, where a written examination is required; also a reexamination may be had in all states one year after applicant has failed in his first examination.

The efficiency of hydraulic machinery in general was commented upon in a paper which Mr. J. A. Boving contributed recently to the Royal Society of Arts. Dealing with air-lift wells, he said that the test and research work recently done in England has proved that with a correct design and proper attention to detail, an efficiency of from 55 to 75 per cent can be obtained. The variation depends on the relation between available fall and desired compression, as well as on the size of the plant. If the same conversion were to be made by water turbines and mechanical compressors, the residual efficiency would be from 35 to 50 per cent.—*The Engineer*, December 13, 1929, p. 635.

Status of the Mechanical Engineer in the Machinery Industries

WHAT salaries are paid mechanical engineers in the metal-working industries? What positions are being held by mechanical engineers? What may be the salary expectations of these engineers at any given age? Answers to these questions must be based on figures representing compensation actually being paid and titles being used.

In 1927 the Executive Committee of the Machine Shop Practice Division of The American Society of Mechanical Engineers sent to its entire membership the questionnaire given on the second following page. The membership receiving the questionnaire numbered approximately 2700. Replies numbered 1460, equivalent to 54 per cent. On the assumption that the salaries and titles given in these replies are representative of the complete membership of the division and that the division membership is truly representative of the mechanical engineers of the machinery industries, the accompanying tables and graphs are presented as showing the status of the mechanical engineer in the machinery industries. The period covered is 1927–1928.

No identification of individuals or companies was intended and none was possible. It was considered advisable, however, to identify replies with states, and, accordingly, the returns were so segregated—the state identity being taken from the post mark. This procedure made possible the presentation of salary data by groups of states.

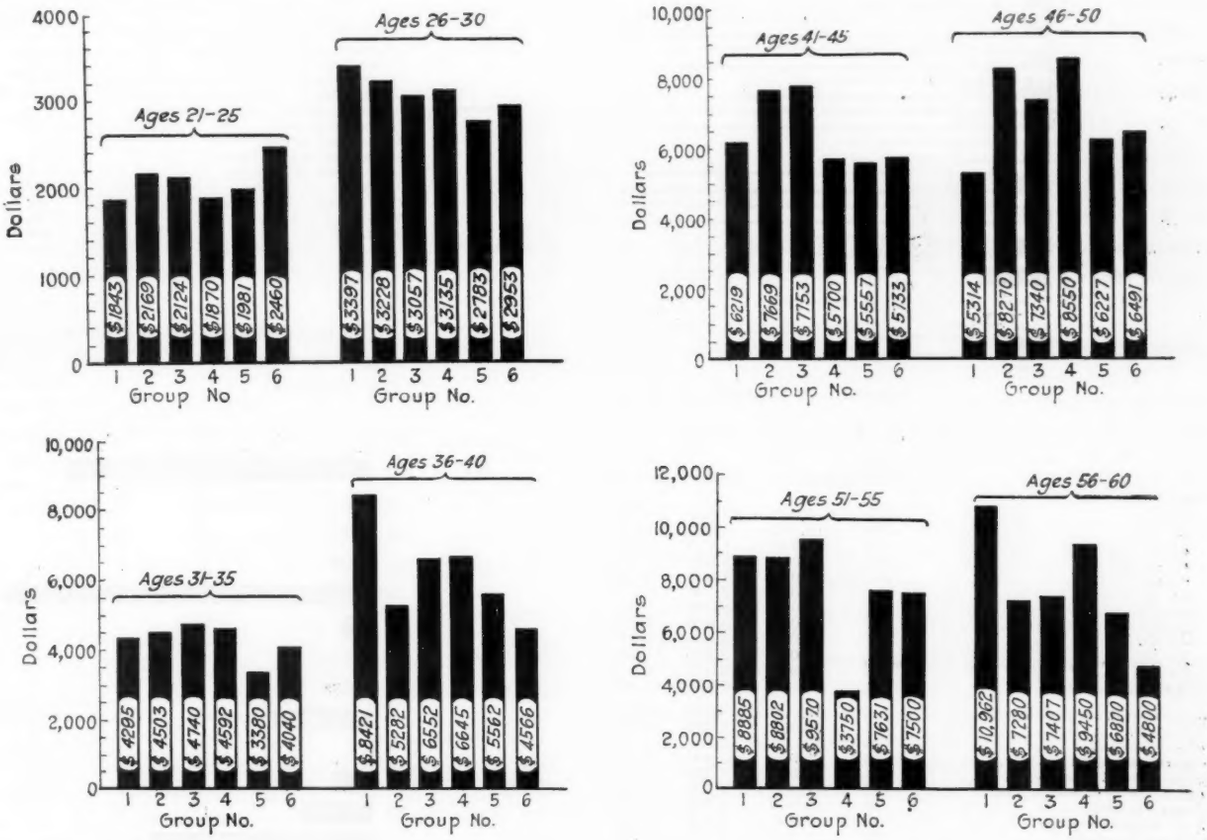
The six groups chosen are as follows:

(1) Maine; Vermont; New Hampshire; Massachusetts; Rhode Island; Connecticut

(2) New York; New Jersey; Pennsylvania; Delaware; District of Columbia; Maryland

(3) Ohio; Indiana; Illinois; Wisconsin; Michigan, Minnesota

(4) Virginia; West Virginia;



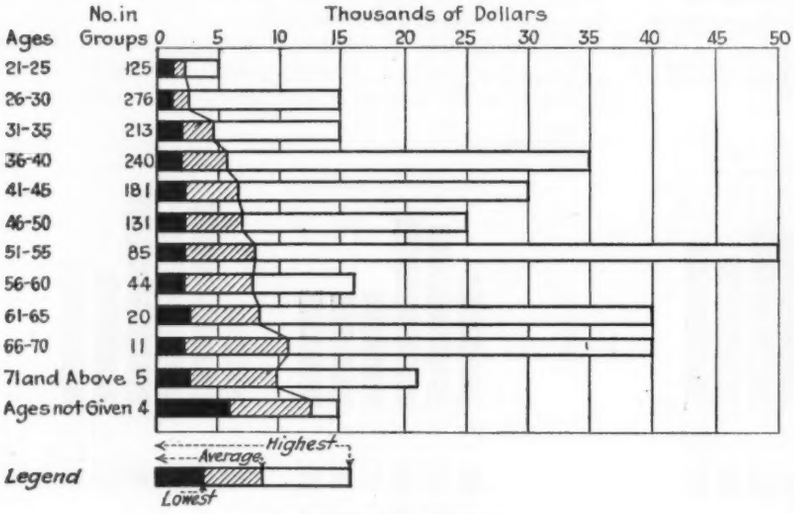
SALARY DATA BY STATE GROUPS

Kentucky; Tennessee; South Carolina; North Carolina; Georgia; Florida; Alabama

(5) California; Washington; Oregon; Nevada; Idaho; Colorado; Texas; Utah

(6) South Dakota; Missouri; Montana; Wyoming; Arizona; New Mexico; North Dakota; Nebraska; Kansas; Oklahoma; Arkansas; Louisiana; Mississippi.

The tables and graphs are self-explanatory.



SUMMARY OF SALARIES

SUMMARY OF SALARIES

Item	Number Reporting	Highest	Lowest	Average
Ages:				
21–25	125	$ 5,000	$1,300	$2,122
26–30	276	15,000	1,320	2,966
31–35	213	15,000	1,690	4,390
36–40	240	35,000	1,620	6,176
41–45	181	30,000	1,800	6,585
46–50	131	25,000	2,100	6,750
51–55	85	50,000	2,000	8,070.50
56–60	44	16,000	2,000	7,952
61–65	20	40,000	2,850	8,326
65–70	11	40,000	2,600	11,507
71 and above	5	21,000	2,800	9,080
Ages not reported	4	15,000	6,000	12,500
Chairman, board of directors	2	15,000	5,200	10,050
President	78	50,000	1,200	10,768
Vice-president	70	50,000	2,100	9,318
General manager	37	25,000	2,400	9,296
Asst. general manager	6	15,000	1,820	4,360
Plant, factory, works, mgr.	72	40,000	2,200	7,413
Superintendent	99	16,000	1,800	5,711
Asst. superintendent	30	7,000	2,000	4,076
General foreman	20	5,500	2,500	3,722
Asst. foreman	8	4,200	2,000	2,585
Inspector	7	6,000	2,500	3,580
Chief engineer	165	15,000	1,500	5,391.50
Assistant engineer	70	11,000	2,000	3,928
Chief design engineer	20	5,460	2,100	3,673
Asst. design engineer	156	8,700	1,320 (750 China)	2,690
Chief draftsman	34	5,000	2,080	3,507
Production engineer	66	15,000	1,768	3,953
Time-study methods	46	10,000	1,685	3,624
Efficiency engineer	7	5,000	1,800	2,920
Equipment engineer	5	4,400	2,392	3,598
Apprentice	53	2,700	1,200	1,777
Sales engineer	54	7,500	1,690	3,512
Consulting engineer	25	20,000	2,400	7,465
Sales manager	15	15,000	4,000	7,501
Tooling engineer	19	7,000	2,080	3,069.50
Branch manager	7	8,100	3,600	5,733
Instructors—professors	54	7,000	1,800	3,451
Secretary and treasurer	17	15,000	2,400	7,030
Clerical	7	3,600	1,560	2,255
Research	32	10,500	1,300	3,550
Miscellaneous	18	10,000	1,430	4,228

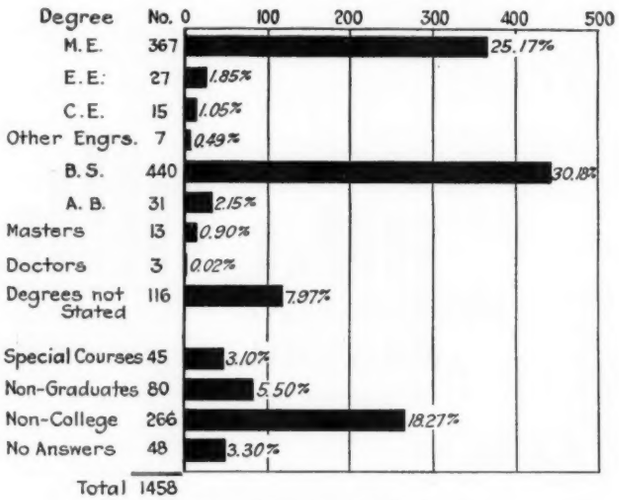
EDUCATION AND DEGREES

An analysis of replies shows 69.2 per cent to be college or technical-school graduates; 5.6 per cent non-graduates, but having some college or technical school training; and 18.2 per cent not having any college or technical-school training.

The following tabulation shows the number holding the various degrees listed:

Degree:	No.	
M.E.	367	
C.E.	15	
E.E.	27	
B.S.	418	
A.B.	31	
M.S.	9	
D.Sc.	2	
A.M.E.	1	
B.M.E.	5	
M.B.A.	1	
Ph.B.	11	
M.A.	3	
B.S.C.	3	
B.S. in Administrative Engineering	1	
L.L.B.	1	
Ph.D.	1	
Metallurgical Engineer	1	
Industrial Engineer	4	
Petroleum Engineer	1	
Graduates, degrees not stated	116	
Total		1018
Special Courses:		
No answer	48	
Correspondence school	10	
Night school	8	
Trade school	5	
Machine design and mathematics	2	
Naval Academy	3	
Vocational school	1	
Home and night study	5	
B. O. trade certificate	1	
Diploma	3	
Certificate	7	
Non-graduates	80	
Non-college	266	
Total		440
		1458

The Questionnaire on the following page was mailed to members of the Machine Shop Practice Division.



EDUCATION AND DEGREES

PROMOTIONS

Depending upon:	Answers Received No.	Per cent (approx.)
1—Politics, favoritism, religion, fraternal, etc. (merit secondary)	292	22
2—Relationship (merit secondary)	204	15
3—Partly to merit, other causes with merit	265	21
4—Wholly merit	877	68
5—Seniority—Civil Service	30	2
6—Ambiguous (no reply)	165	12
	1833	120

In the above tabulation the percentage column totals more than 100 per cent (120 per cent) because in some cases two or more distinct bases for promotion were given so that a count was given in the respective columns as from the same reply.

In Item (1), merit was either secondary when considered at all, or else totally lacking. In Item (2), relationship was particularly stressed in many replies so as to justify giving it distinct consideration. Under Item (4) no other consideration than merit was given. Seniority and Civil Service are so closely allied as to warrant their joint consideration (Item 5).

SURVEY RELATIVE TO THE STATUS OF THE MECHANICAL ENGINEER IN INDUSTRY

1. From what college (if any) did you graduate?
2. Year of graduation.
3. Degrees and years conferred.
4. Present age.
5. Present position in your company.
6. Present salary per year.
7. If you have held any of the positions mentioned in the next column, please indicate year, at what salary, and if with present or other concern.
8. What are the products of the plant in which you are now employed?
9. State the total number of employees in the organization (all classes).
10. If the company operates more than one plant, state how many.
11. Has your company an apprentice or student course?
12. In what branches of engineering is such instruction given?
13. What is the prescribed time for the course?
14. Is it required of all engineers in your company that they be college graduates?
15. What engineering training other than regular college courses have you had (such as correspondence school, vocational school, university extension courses, etc.)?
16. Is promotion in your company dependent upon politics or relation to some high executive through birth or marriage, or does merit rule?

a. Chairman of Board
b. President
c. Vice-President
d. General Manager
e. Works Manager
f. Superintendent
g. Assistant Superintendent
h. General Foreman
i. Assistant Foreman
j. Inspector
k. Chief Engineer
l. Assistant Engineer
m. Designing Engineer
n. Chief Designer
o. Chief Draftsman
p. Production Engineer
q. Efficiency Engineer
r. Time Study and Methods Engineer
s. Equipment Engineer
t. Apprentice Engineer
u. Sales Engineer
v. Sales Manager
w. Consulting Engineer
x. Tooling Engineer
y. Other positions

NOTE. DO NOT SIGN THIS QUESTIONNAIRE. Your cooperation and sincerity in answering the questions as fully as possible are all that is asked. Mail in enclosed return envelope.

Reliability of Fusible Tin Boiler Plugs in Service

IN COOPERATION with the Steamboat Inspection Service a study has been made at the U. S. Bureau of Standards of reliability of fusible boiler plugs of the type installed in ship boilers under the jurisdiction of the Inspection Service. It has been found that under certain conditions fusible plugs would not operate due to the formation in service of a refractory oxide replacing the tin in the fire end of the plug. This obviously constitutes a very dangerous state of false security.

The Steamboat Inspection Service requires that plugs shall be renewed at each annual inspection except in cases where plugs were installed or renewed not more than six months prior to annual inspection, in which case they may be allowed to remain until the next following annual inspection, or for a period not to exceed 18 months.

A total of 184 plugs were received from the Steamboat Inspection Service and examined. The data indicate that approximately 10 per cent of the plugs examined would not have functioned in service. The average time in service of all of the plugs examined was 10 months.

The cause of the failure to function was evident in every case. It was always due to the presence of a hard, "infusible crust" packed tightly in the fire end of the plug and replacing some of the tin filling. In general, this deposit was apparent upon inspection, but in many cases, especially when the tin in the fire end had been melted out for an appreciable distance back in the plug, it was difficult to determine its presence, and in some instances a plug which was apparently in good condition failed to function in test because of it.

It is evident that the tin melted during test and that the plug would have functioned except for the obstruction which had formed in the fire end during service. This is typical of all plugs that failed to blow out in test.

The cause of the formation of the deposit of "infusible crust" was not at first apparent. Chemical analyses of these deposits are given in the original article, together with the composition of the tin filling after test in the "blow-out" apparatus.

Chemical analyses were also made of the tin blown out of many of the plugs that functioned properly. It is evident that, in general, the tin after test conforms to the specification requirements except for the copper content, which undoubtedly increased during the test, as discussed later in the report.

Further tests have shown that the type of firing, i.e., coal or oil, has no apparent relation to the formation of the infusible crust. Neither does there seem to be any relation between the crust formation and the pressure in the boilers in which the plugs were used. Data are not available regarding the positions from which the plugs tested were taken.

It is of interest to note that of the total of 18 plugs that failed to function in the tests, 15 were outside plugs and only three inside plugs, a ratio of five to one. These data are rather too few to allow drawing any general conclusions, but they indicate the desirability of having in all plugs the least possible length of projection of the fire end beyond the boiler shell into the fire chamber.

Chemical analyses of the infusible crusts indicated that they were chiefly stannic oxide (melting point, 1127 deg. cent.) with oxides of other metals present, and in some instances a surprisingly large percentage of calcium sulphate (melting point, 1360 deg. cent.).

The general rules and regulations of the Steamboat Inspection Service require that "fusible plugs shall be so fitted that the smaller end of the filling is exposed to the fire, and shall be at least 1 in. higher on the water side than the plate or flue in which they are fitted." Under these conditions it would be expected that any molten tin in the fire end of the plug would run out. This occurs in the majority of cases. In fact, it is probable that the tin filling is melted out of the fire end after very few days or hours of service.

The formation of the "infusible crust" in some cases was believed to be due to the melting of the tin in the fire end and its being prevented from dropping out due to the presence of ash or other obstructions. The tin then apparently oxidized, together with some of the copper from the casing, eventually replacing the tin in the fire end with a hard mass of very high melting point. In other instances the formation of the crust was found to be due to a small leak in the plug, permitting boiler water which may have contained appreciable amounts of calcium and magnesium sulphates and carbonates reaching the fire end. Here it would be evaporated but would leave a small deposit of the dissolved salts. Over a long period of time these deposits apparently become appreciable, and eventually form a hard, compact mass in the fire end.

Certain recommendations in this regard are made at the end of the paper.—John R. Freeman, Jr., J. A. Scherrer, and S. J. Rosenberg, *in Bureau of Standards Journal of Research*, vol. 4, no. 1, Jan., 1930, pp. 1–22, 5 tables, 8 figs.

Survey of Engineering Progress

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

The Sikorsky Multiple-Disk Brake

THIS is a brake developed for the Sikorsky amphibian planes, and is said to be enabling them to land within a space of 300 ft. Because of its large size, an ordinary self-energizing brake is not sufficient for the Sikorsky amphibian, while greater self-energization seemed to be out of the question due to the possibility of the brake's locking.

The multiple-disk brake offers practically unlimited possibilities for having large braking surfaces. The difficulty in using large surfaces is, however, the problem of getting uniform pressure over the braking areas without unduly heavy construction. Most of the experimental work in connection with the brake development was an effort to get this even distribution of pressure without undue weight.

There are three stationary plates, the outside and inside ones having brake lining riveted to one side only, while the center plate has brake lining riveted on both sides. The duty of the arms of these stationary plates is to support the brake lining and to carry the braking torque inward to the axle. These plates are but sixty-two thousandths of an inch thick, and yet, due to the placing of the metal in line with the stresses, these three plates will carry safely to the axle a torque in excess of 25,000 in-lb., which, translated into plain English, means that there is a turning action on the bolts holding the stationary plates to the axle flange of slightly more than 12,000 lb. (*U. S. Air Services*, vol. 14, no. 12, Dec., 1929, p. 72, 1 fig., *d*)

Navy Work on Motor Development

THE Bureau of Aeronautics, U. S. Navy, has announced results of work now being done at the Aeronautical Engine Laboratory, Naval Aircraft Factory, Philadelphia, Pa. It deals primarily with the use of special anti-freeze compounds as affecting the design of high-temperature motors. The high-temperature cooling material used was Prestone.

Among the coolants tried, besides water and Prestone, were Halowax oil and Carbitol, and Carbitol proved to be second best. It was found, among other things, that coolant outlet temperatures of 350 deg. may be used to advantage in water-cooled aircraft engines by making piston-ring side clearances commensurate with those used in air-cooled engines having a similar bore. Aluminum wristpin plugs are more suitable than brass plugs.

A closed system without a radiator was given a short trial. Although only a short full-throttle run was made, it was shown that a system of this type has possibilities.

Because of its ability to withstand the high cylinder temperatures, coupled with the fact that it caused no appreciable loss in power, 120-viscosity paraffin-base lubricating oil is considered to be preferable for high-temperature cooling. A 200-viscosity oil was tried to determine its effect on operation, but, due to the extremely heavy oil, a considerable loss of power resulted, and the oil was discarded in favor of the 120-viscosity oil.

When operating at a 350-deg. coolant outlet temperature, the small amount of radiation required if supplied by the addition of cooling fins to the cylinder blocks would reduce the amount of plumbing required. This also suggests that the difficulty encountered in air-cooling engines with cylinders in line would be overcome by using a cooling system of this type. (*U. S. Aviation Quarterly*, vol. 1, no. 1, June-Aug., 1929, p. 43, *e*)

AUTOMOTIVE ENGINEERING (See Machine Parts and Design: Reo Composite Herring-bone Gears)

ELECTRICAL ENGINEERING (See also Engineering Materials: Thyrite—Both an Insulator and a Conductor; and Mechanics: Practical Application of a Relativity Principle)

A New Type of Three-Phase Commutator Motor

THIS motor has been developed by the German General Electric Co. and is principally intended for drives of small and medium output for which cascade connections or conversion to direct current would not be appropriate.

In this motor the stator is connected to the mains so that the rotating system operates only at a low voltage. Speed regulation is effected by adjusting the induction regulator fixed integrally to the stator frame and by simultaneously moving the brush rocker coupled to it by gearing and a toothed-wheel segment, both of these movements being controlled by a common handwheel. The smaller-size motors are equipped with a built-in switch positively connected in or out by the brush rocker and thus automatically controlled by the same handwheel. Remote control is, however, possible. In addition to this it is possible to put in a motor-driven adjusting device which renders push-button control applicable. As a rule the speed of the motors can be varied in the ratio of one to three at full-load torque. The efficiency curve of the motor is flat over the entire range of regulation. The power factor equals unity at the top speed, and at the synchronous speed is higher than that of an asychronous motor of the same output. (*AEG Progress*, vol. 5, no. 10/11, Oct.-Nov., 1929, p. 331, 2 figs., *d*)

ENGINEERING MATERIALS (See also Special Machinery: Riveted and Welded Bridges)

Metal Hard-Facing

HARD-FACING is defined as the process by which a thin veneer or overlay of hard, abrasion-resistant alloy is applied to any metallic surface by welding with the oxyacetylene torch or electric arc. Both alloys and methods of application are quite numerous. Hard-facing was first developed in connection with petroleum exploration work in California, where petroleum deposits were located at depths of more than 7000 ft. below the surface. The severe service to which the drilling tools were subjected led to a search for some practical means of increasing the durability of the cutting edges, and hard-facing proved to

be an efficient method of doing this. Stellite seems to have been the first to be used for rebuilding worn-out oil-well tools. Later on, several other alloys were developed for this purpose, such as Stoodite, by the Stoody brothers, at Whittier, Calif.

Quite a number of alloys have been developed for specific purposes, but are applicable to a wide range of hard-facing work. In general, these alloys are of three classes. The first consists of welding rods that may be fused to the surface of the tools, leaving a deposit which is abrasion resistant to a certain degree, and which, when used as an overlay, will provide a tough as well as an abrasion-resistant surface.

The second class includes alloys that may also be fused to the tool metal, but that leave a deposit which is still harder than that of the first class, but which has a tendency to develop brittleness if the cutting edges are unsupported or are not properly backed up. The third class comprises what are known as "diamond substitutes." These fused alloys are too hard and have too high a melting point to be fused to the tools, and are applied by either brazing or welding around them sufficiently to hold them in place. The latter class of alloys is used for core-drilling tools and for tools employed in cutting through unusually hard materials.

The "Self-hardening Rod," "Stoodite," and "Borium" alloys are examples of alloys covering the first, second, and third classes. Hascrome, Haynes Stellite, and Hatstellite, manufactured by the Haynes Stellite Co., will also fulfil the requirements of all three applications. The Mills Process Alloys Co. specializes more particularly in the third class of alloys, which it markets under several trade names. The Blackor Co. and more than half a dozen others market more than one class of alloys.

The author discusses the theory of the mixed-alloy welding rod and the general problem of hard-facing alloys.

Of late many so-called "diamond substitutes" have been placed on the market which are claimed to be adaptable to hard-surfacing as well as to applications formerly employing industrial diamonds. These diamond substitutes, aside from their method of application and the fact that their hardness prohibits ready grinding to smoothness after they have been applied, may be classified with the other hard-surfacing alloys for all processes with which machine design is concerned. They have been found especially well suited to the requirements of oil-field tool work, because no particular surfacing other than that secured in their application is necessary. For other types of equipment their selection would be economical only where the cost of finishing them to the required smoothness would be permissible or where no finishing at all was required.

The author claims that under certain conditions hard-facing is preferable to heat treatment. (Miles C. Smith in *Machinery* (New York), vol. 36, no. 3, Nov., 1929, pp. 219–222, 6 figs., *dp*)

Zinc-Base Die Castings

THERE are two principal kinds of zinc-base die castings, namely, gravity and pressure castings. The former are sometimes classified as slush castings and permanent-mold castings. The pressure castings are thought to be very much stronger as a rule than gravity castings. The automobile industry consumes well over 50 per cent of the zinc-base die castings now being produced. There are three types of die-casting alloys, and the article here abstracted gives their compositions and physical properties. The commonly termed "Tin Alloy" has low physical properties, but is quite readily soldered. The next group, known as 4–3 or 5–3, contains from 4 to 5 per cent of aluminum and 3 per cent of copper, the remainder being high-grade zinc. This type of alloy has a tensile strength from 37,000 to 43,000 lb. per sq. in. and an average elongation of 2 to 3 per cent in 2 in. It casts well, with a smooth surface which makes subsequent buffing and plating easy.

The 4–3–0.01 alloy (Zamak) is composed of 4 per cent aluminum, 3 per cent copper, 0.01 magnesium, and the remainder high-grade zinc. This is the most modern alloy, and in many cases it has replaced previous alloys because of its high tensile strength (47,000 to 50,000 lb. per sq. in.) and ability to cast well in complicated forms and with a smooth surface. The author gives figures showing the comparative physical properties of zinc-base die castings and of castings made of other materials. It is estimated that the production of zinc-base pressure die castings consumed well over 60,000,000 lb. of high-grade zinc in 1928, and the demand is still growing. (Robt. M. Curts, Technical Service, N. J. Zinc Company, N. J., in *The Iron Age*, vol. 124, no. 25, Dec. 19, 1929, pp. 1655–1658, 12 figs, *pc*)

Thyrite—Both an Insulator and a Conductor

AN ENTIRELY new type of material, one that is both a good insulator and a good conductor of electricity, was announced by K. B. McEachron of the General Electric Company at the winter convention of the American Institute of Electrical Engineers in New York City on January 27. This material, which has been called "Thyrite," meaning gate or valve, has the remarkable property of changing its resistance to the flow of electricity as the voltage or pressure is changed. This change in resistance is such that each time the applied voltage is doubled the resistance decreases so that the current flow is increased more than 12 times. This means that if the voltage is increased 16 times the current flow is increased more than 25,000 times.

The usual conductor with which electrical engineers are familiar does not change in resistance except when the temperature of the conductor changes. To illustrate, the tungsten filament in the Mazda lamp increases its resistance considerably as the filament heats up; the carbon lamp, made memorable by the work of Edison, shows, on the contrary, a decrease in resistance as the filament increases in temperature. With either of these materials the resistance change is slow since it depends on the time required to heat the filament. Unlike any materials now in commercial use, the resistance change of Thyrite does not depend on the temperature, but on a change in the applied voltage. Thyrite will change its resistance as quickly as the applied voltage changes; in fact, tests have shown that the resistance can be decreased to a millionth of its original value in a time as short as a millionth of a second.

Thyrite is a manufactured product which required more than five years of intensive research to develop to the state where it could be produced commercially. Mr. McEachron exhibited some disks 6 in. in diameter and $^3/_4$ in. thick, made for use in lightning arresters for the protection of power stations against the damaging effects of lightning. Such disks have a resistance of about 50,000 ohms when 100 volts are applied to the parallel faces; the resistance decreases to less than one-half an ohm when the voltage is increased to 10,000 volts. These disks of Thyrite will carry lightning discharges having currents as high as 30,000 amperes without any sign of distress.

The characteristics of Thyrite are permanent. Some of the first material made is still on life test, with no change in its characteristics, even though it has been carrying current continuously night and day over a period of several years.

Thyrite resembles black slate in color. It has mechanical properties similar to those of dry-process porcelain. In manufacturing it, the material is molded to the shape required, and the contact surfaces coated with metal by the Schoop metal-spraying process.

It is possible to use the material successfully on any alternating- or direct-current circuit; it is necessary only to supply a proper

amount of the material so that it will not become overheated.

In connection with lightning arresters, Mr. McEachron explained that the use of Thyrite allows a considerable reduction in the space occupied by the arrester, and that it is possible to calculate its performance accurately. This feature will be of great assistance to engineers using such protective equipment. Furthermore, it was pointed out, it is possible for any one to determine the characteristics of Thyrite over a considerable current range, without the use of expensive equipment. (*Publicity Release, General Electric Co.*, Schenectady, N. Y., Jan. 27, 1930, 3 pp., *d*)

FUELS AND FIRING

The German Tormin Process of Low-Temperature Carbonization

THE principle of the Tormin retort embodies the use of a series of circular, slowly rotating, cast-iron disks of large diameter, placed close together, carried by a central horizontal shaft and having a charge of crushed or coarsely pulverized material between, approximately 2 to 3 in. thick. No feed ram is used for the raw fuel. The compression of the charge is given partly by the resistance to expansion of the swelling material and partly by the use of three disks to form one carbonizing cell or unit, with two slabs of fuel. The usual conditions of carbonization obtain, say, 480 to 595 deg. cent., while the duration of heating for each particle of the charge is 2 to 4 hr. Little information has appeared hitherto on this process, and some of the details are not yet clear. In 1929 Tormin erected at a colliery in Westphalia an experimental retort of one carbonizing cell only 2 meters in diameter. This is described and illustrated in the original article. The briquets are in the form of diamond-shaped, very dense, strongly compressed, smokeless low-temperature-fuel blocks, and their peculiar shape is said to have been found by experience to give the best results in the retort, allowing the molds to close up smoothly and uniformly, one after the other, without taking more coal than can be compressed efficiently, any excess being squeezed out into the next mold not yet completely filled in the cycle of operations.

It should be pointed out that all these diamond-shaped molds communicate with one another by very narrow apertures at the top and bottom, but this jointing is fragile and easily breaks when the fuel is discharged, giving, therefore, separate briquets. Also, of course, the whole design of the retort setting, containing any desired number of disks, is so arranged that—depending upon the temperature of carbonization, the speed of rotation, and the coking properties of the individual coal—the highest pressure of "nip" between the disks takes place at the maximum point of plasticity, which generally occurs in most coking coals between the range of 205 to 370 deg. cent. A number of different modified designs of the Tormin retort are available, but they are all on this same general principle of subjecting the solid material to a gradually increasing pressure between rotating disks of peculiar shape so as to obtain small diamond-shaped blocks of fuel, with external heating under low-temperature conditions, while rotating at an extremely slow speed.

Among other things, it is stated in the article that the Dobbelstein process has now been merged in the Plassmann process, and that the latter retort consists of a special design of very large vertical cylindrical steel unit built up of a series of alternating flat carbonizing cells about 4 in. deep and heating compartments of the same size. In the latest design of the Plassmann retort now being completed at the plant of Coal Conversion, Ltd., at Barking, London, the retort weighs 170 tons and there are 21 heating chambers. The author gives also some data on the Raffloer process, which employs a long rotary cylindrical steel retort, externally heated and containing inside a series of longitudinal narrow gutters. The cylinder revolves very slowly and intermittently, and at each movement one of the gutters is subject to the powerful action of a reciprocating ram which adds a small proportion of raw coal and at the same time pushes along the entire contents of the gutter. (David Brownlie in the *Iron and Coal Trades Review*, vol. 119, no. 3225, Dec. 20, 1929, pp. 939–940, 1 fig., *d*)

MACHINE PARTS AND DESIGN

Reo Composite Herringbone Gears

THIS gear was invented by H. T. Thomas, chief engineer of the Reo Motor Car Co., and is used in the new Reo transmission. One half of this gear has one pitch, while the other half has a different pitch. The difference in pitch is sufficient to make the gears readily distinguishable. Comparatively fine pitches are used for automobile transmissions, running from 9 to 18 normal diametral pitch. The ratio of one half of a pair of composite herringbone gears must be exactly the same as the ratio of the other half. Varying helix angles of from 27 to 51 deg. were tried.

This gear, while avoiding the exacting engineering requirements, and practical difficulties of internal gears, adapts itself to the desired ratio and design and utilizes many of the characteristics of other types of quiet gears, such as spur, helical, and spiral bevel, viz., deep teeth, long addendum, conjugate tooth contact, generous overlap, long line of action, plus that precision refinement of supplemental addendum bearing on the driving profile of the tooth which invariably is a feature of quiet-running spiral-bevel rear-axle gears. This highly important addendum bearing is produced by the design and grinding of the cutters, and sizes of the mating gears.

Not the least of the factors in this combination for quiet power transmission is the action of a gear of one particular pitch secured to a gear of a different pitch so that the vibrations set up by one half of the gear are nullified by the action of the other half, on the principle of the interference of sound or non-harmonics. This principle being applied at the source, carries the gear through the critical periods without sound-causing vibrations. (Letter by Arthur Nichols, Gear Research Dept., Reo Motor Car Co., published in *Automotive Industries*, vol. 62, no. 2, Jan. 11, 1930, p. 58, *d*)

MACHINE-SHOP PRACTICE

Cutting Capabilities of Lathe Tools

AN INTERESTING part of this paper deals with cutting-tool alloys other than steel, such as Stellite and Widia. A recent production in this class is Perdurum. Little is known of its cutting properties. Its hardness on the Moh scale is 9.8, which means very close to the diamond. It is used as a tip material, and brazed to its support by silver solder at a temperature of 720 deg. cent. with borax as a flux.

A Perdurum tool, when cutting mild steel at a speed of 139 ft. per min. with a cut $^3/_{16}$ in. deep and $^1/_{16}$ in. traverse, lasted for 4 min. 48 sec., when the tip fractured and broke down, due to the pounding action of the cut. A further trial was made with a fresh tool on a hard-steel bar (Brinell hardness 255) at a speed of 220 ft. per min. when taking a cut 0.05 in. deep on a traverse of $^1/_{72}$ in., when the tool lasted 11 min. At the end of this period there was a slight scar on the front face of the tool. Another tool was put to test on a hardened steel ball race (Brinell No. 600) at a cutting speed of 145 ft. per min. on a cut $^1/_{100}$ in. deep by $^1/_{100}$ in traverse. After cutting for about $^1/_2$ min. the tool was withdrawn, and found to be in good condition. These

tests, however, were not sufficiently prolonged to make a fair pronouncement of the cutting capabilities of this material.

The author then discusses the heat treatment of tool steel and tests of tool and material. His discussion of the cutting speed with heavy cuts is based on previously published reports of the Manchester Lathe Tool Committee. (Paper presented to the North-East Coast Institution of Engineers and Shipbuilders; abstracted through *Mechanical World and Engineering Record*, vol. 87, nos. 2244 and 2245, Jan. 3 and 10, 1930, pp. 3–6, and 27–29, 8 figs., not completed, *e*)

MACHINE TOOLS

A Heavy-Duty Thread-Milling Machine

THE capacity of the machine here considered for bars, tube, or pipe is up to 10 in. in diameter. Threads on flange work somewhat larger in diameter can be cut by chucking the pieces. The rated capacity of the machine is to cut two threads per inch with 8 in. face at one cut. The machine has been primarily developed (Lees-Bradner Co., London) for the milling of oil-well tools, tool joints, drill pipe, and shafts, and is equipped for straight turning, facing, and chamfering operations.

The thread-milling head is designed to eliminate vibration and is mounted as unit on a carriage provided with rapid traverse along the bed.

The cutter spindle is a heat-treated alloy-steel member, with a No. 18 B. & S. taper and clutch drive at the front end. It is mounted in tapered hard-bronze bearings, and is driven by a 10-hp. motor through a combination of double-helical and worm gearing, a heavy flywheel being mounted on the back end of the pinion shaft. The arrangement gives a range of six spindle speeds, and is designed with a view to avoiding chatter or vibration of the spindle.

Provision is made for swiveling the cutter head up to 2 deg. to insure parallelism, a 4-to-1 geared micrometer screw $3^1/_2$ in. in diameter providing the means for regulating the depth of cut. Means are also provided for accurate recutting and reproduction of size.

The rapid-traverse motion, which is applied to the main saddle, facilitates loading and braking at the end of a cut, adjustable stops being fitted to limit the movement of the carriage, which are additional to auxiliary automatic safety stops.

For slow movement of the carriage, when cutting threads, a set of clamping blocks is provided. By raising a lever on the carriage, these blocks are solidly locked to the lead-screw bar, and the entire cutting unit is then traversed at a uniform speed to produce the required lead of thread.

The lead screw is provided with a $^1/_2$-in.-pitch thread 20 in. long at one end. This thread runs through a revolving nut in the lead-screw change-gear housing at the extreme end of the machine. Drive to the nut is derived from a change-gear shaft through pick-off gears that give the required lead of thread, right or left hand. The lead-screw unit is itself driven by a shaft directly connected to the wormshaft that drives the cutter spindle.

The method of traversing the lead screw through a nut which is rotatably mounted, but stationary endwise in relation to the bed, and of locking the carriage to the lead screw during milling, is claimed to eliminate backlash, and also enables the carriage to be returned to its original position for accurate recutting.

By using a movable cross-slide mounted on the carriage and connected to a shoe riding on a taper bar at the back of the machine, tapers up to 3 in. per ft. in either direction may be milled with the same ease and precision as straight threads. (*Machinery* (London), vol. 35, no. 896, Dec. 12, 1929, pp. 365–366, 3 figs., *d*)

MECHANICS

Practical Application of a Relativity Principle

THE paper here abstracted deals primarily with the Norinder cathode-ray oscillograph as used in lightning investigations on transmission lines. In an appendix thereto an attempt is made to develop a simple and concise formula for the sensitivity of a cathode-ray oscillograph.

There is a well-known formula for computing the deflection of electron jet due to a homogeneous electrostatic field. For most cases this formula is accurate enough; yet at a cathode voltage of 60 kv. it already introduces an error of about 5 per cent because it neglects certain relations between mass and speed which assume importance at velocities approaching that of light. This has long been realized, and it is possible to account for the error by means of an elaborate system of equations. In this instance an entirely different path has been struck by accepting one outstanding conclusion of the theory of relativity, namely, that electromagnetic energy has momentum, or, in the more generalized form of Einstein's theory, that energy in any form has inertia or mass. A formula has been developed for the mass of a particle in motion where one of the members represents the increase in mass due to the kinetic energy acquired. In the case of an electron jet the kinetic energy of the electron which has traveled from cathode to anode and then has passed through the anode hole is equal to the product of the potential difference between cathode and anode and the charge of the particle. With this as a basis an expression has been derived for the magnitudes involved in determining the deflection of an electron jet, particularly for the value of the fraction representing the tangent of the angle of deflection. [It must be clearly understood in this connection, that while recourse has been successfully had to the Einstein theory of relativity, this should not be taken in any way as a proof of the correctness of the theory, as it merely shows that particularly valuable results can be obtained from the application of certain principles of that theory without regard to the broader question of its general correctness as such and its present mode of expression.—ABSTRACTER.] (Paper by O. Ackermann, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa., presented at the Winter Convention of the *American Institute of Electrical Engineers*, Jan. 27–30, 1930; abstracted from preprint, 8 pp., 14 figs., including list of publications on cathode-ray-oscillograph design and devices for the automatic recording of electric transients by means of the cathode-ray oscillograph, *ed*)

POWER-PLANT ENGINEERING

160,000-Kw. Generator of the New York Edison Company

THIS generator, recently installed in the 14th Street Station of the New York Edison Co., is the largest single-shaft unit yet built; it is a 160,000-kw., unity-power-factor, three-phase, 25-cycle, 1500 r.p.m., 11,400-volt type. The stator, for reasons of handling and shipment, had to combine exceptional lightness with strength of frame. This was secured by eliminating all castings in the frame design, and instead, using a welded-plate construction.

The rotor consists of three separate steel forgings: a hollow body section and two solid end pieces, which were shrunk and bolted solidly together. Heavy steel rings are fitted over the end projections of the field windings, holding them in place against centrifugal force. The body part alone weighs 228,000 lb.

Ventilation for the generator is supplied by four centrifugal blowers, which circulate the air in a closed-circuit system. Surface coolers are provided for removing from the ventilating air the heat absorbed by it in passing through the generator. In most large turbine-generator installations employing the closed-

circuit system of ventilation, the air coolers are placed beneath the floor and connected into the ventilation system through ducts. Such an arrangement of the coolers was not possible for this generator, owing to the limited space below the machine.

The arrangement used is shown in Fig. 1. The coolers are located above the floor and on either side of the generator, within a large sheet-iron housing, which also encloses the generator. The blowers are placed below the floor, two on either side of the generator, and housed together with their driving equipment

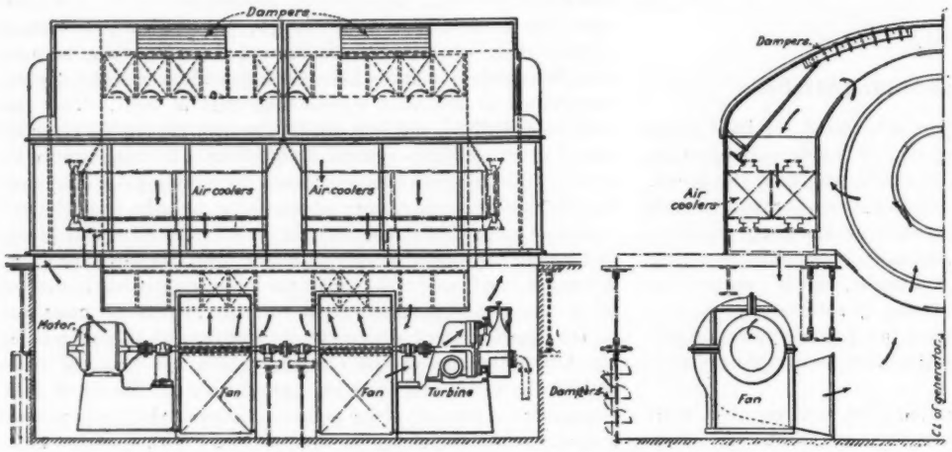


FIG. 1 OUTLINE OF THE VENTILATING SYSTEM OF THE 160,000-KW. SINGLE-SHAFT GENERATOR, NEW YORK EDISON COMPANY

in chambers which are located directly beneath the coolers.

Each pair of blowers is coupled together and arranged to be driven normally by a single 200-hp. 1440-r.p.m. induction motor connected to the shaft of the pair of blowers. To insure that the ventilating-air supply to the generator would not be interrupted by failure of the alternating-current power to the blower motors, a small single-stage steam turbine is also connected to each pair of blowers. The turbines are normally operated idling, and are automatically placed in service if the voltage to the motors fails. The four blowers furnish approximately 160,000 cu. ft. of air to the generator per minute, at a static pressure of 9 in. of water.

The arrangement of the ventilation system used with this generator has never before, so far as it is known, been used in this country. It possesses several advantages over other arrangements that have been used, principally in simplicity, compactness, and accessibility. The first two of these advantages are the reduction to a minimum of the duct work outside the generator, while an unusual degree of accessibility is gained by locating the coolers above the floor level. The necessary air passages for conveying the ventilating air to and away from the coolers are located within the ventilation housing. The duct work is reduced to a minimum by enclosing each pair of blowers with its driving equipment within a common chamber. Doors are opened at either end and on each side of the ventilation housing, which open into inactive air spaces at the ends of the coolers, thus permitting inspection or repairs to the coolers and their piping while the generator is in operation.

The rotor windings are cooled by air entering from the end bells and discharging through openings in the retaining rings and rotor body into an air gap. The air coolers are arranged in four groups of two cooler sections each, two groups on each side of the generator. Raw salt water is used for the cooling medium. (D. S. Snell, A. C. Engineering Dept., General Electric Co. in *Power*, vol. 70, no. 27, December 31, 1929, pp. 1030–1033, 7 figs., *d*)

A New German Water-Tube Boiler

IT IS STATED that a new boiler of the water-tube type has been developed by Keilmann & Voelcker, of Bernburg. While in a normal water-tube boiler the combustion chamber lies under the steam raiser and has only a relatively small radiative surface, the design of the new Voelcker boiler is such that the combustion chamber and the surface heated by radiation are arranged at about the same level, while the drums and tubes that are heated by contact with the combustion gases are situated at a lower level. The tubes of the upper radiation nest end in sectional headers which are connected by upper steam pipes and lower water pipes with the steam chamber, from which the steam flows to the superheater, while the water returns by non-heated down tubes to the lower water chamber. In the whole system the fire gases first heat the upper tube nest by radiation, then the superheater, and finally the lower nest between the two lower water chambers. The intermediate water chamber is carefully insulated.

The principal advantage claimed for this design is that the water circulation is better than in boilers of the normal design, in particular because the static differences between the heated tubes and the non-heated down tubes are very considerable. In the upper tubes there are arranged separators, by which the steam and water are separated and which have the advantage that if any scale deposits are formed they adhere to them and not to the inside of the tubes. Though the boiler is divided into two entirely separate parts, its height is not very great. It is practically suspended by the intermediate water chamber, which is the only supported part. Thus all other parts are entirely free for expansion.

A trial boiler of this design, now under construction, is provided with a mechanical stoker and will be fired with raw lignite. The heating surface will be about 1000 sq. ft., and the pressure 500 lb. per sq. in. The boiler will be used in conjunction with another water-tube boiler of the usual design and of the same size, so that comparative trials may show whether the new design has in practical use the advantage found in laboratory trials. (*Times Trade and Engineering Supplement*, vol. 25, no. 598, Dec. 21, 1929, p. 336, *d*)

Coal-Dust Firing for Lancashire Boilers Without a Pre-Furnace

LANCASHIRE or similar fire-tube boilers are extensively employed in steam-raising plants at coal mines. The application of coal-dust firing to these boilers, which commercially has obvious advantages, has not technically been an unqualified success. In the early attempts to apply coal-dust firing to cylindrical boilers the methods tried were those which had proved suitable for water-tube boilers, and accordingly a pre-furnace or combustion chamber was provided in which the coal dust was burned and in which the ash or slag was in part separated from the combustion gases. Series of such experiments were made in Germany and all proved to be unsatisfactory, chiefly on account of the ash difficulty and the short useful life of the chambers,

which increased the cost of operation. In fact, it was found that the cost of renewals of chambers and of refractory material balanced any saving due to reduction in the stoking labor.

Attempts were made therefore to develop a method of firing without a pre-furnace, the aim being to obtain a thermal efficiency of 70 per cent without a superheater but with preheated air for combustion, a steam production of about 5.75 lb. per sq. ft. of heating surface per hour, and to operate continuously for four weeks without shutting down the boiler for cleaning from flue ash and slag, or from other causes.

In meeting these requirements it was necessary to adapt the coal-dust firing arrangements to the existing equipment of the fire-tube boiler used. Two outlets of the existing coal-dust container were each provided with a worm feeding device, one for each of the two fire tubes. The rate of revolutions was made variable by friction control, to give the desired rate of feed.

At the end of this feeding device, the coal dust was taken up by the surrounding air stream, with sufficient force to prevent a blockage of the supply tubes. In this way a uniform supply of

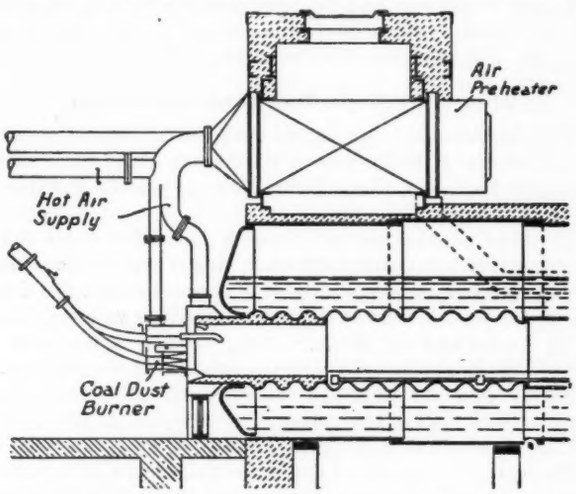


FIG. 2 FIRE-TUBE BOILER WITH COAL-DUST FIRING WITHOUT PRECOMBUSTION CHAMBER

fuel to the burner, which is an indispensable condition for the good working of coal-dust firing without a combustion chamber, was assured. Before its entry into the fire tube, the coal dust and air mixture was split into three streams by means of a distributer, and delivered through the cross-form outlet of the burner in dense clouds directly in the fire tube.

Primarily, only sufficient air was mixed with the coal dust to insure its free passage through the tubes, and the remaining combustion air was supplied through nozzles arranged so as to produce considerable turbulence. The air was delivered under a pressure of 4 in. water column by means of a motor-driven fan, after having been preheated to about 200 deg. cent. in a plate-type air preheater. The coal dust and air were not mixed prior to their admission into the fire tube, and the coal dust, as fed, was so dense that it only formed a combustible mixture on expansion. By feeding in this way, ignition first effected combustion on the surface of the mixture, the center undergoing a kind of coking and gasification through the radiant heat. At a point where this gasification had proceeded far enough, the additional air from the air nozzles was blown into the flame at acute angles, and the fuel-air mixture thus given considerable turbulence so that it burned with a short flame.

On starting up, the fuel-air mixture was ignited by means of an ignition torch or a gas burner, the radiant heat thereafter maintaining ignition. In order to protect the fire tube against excessive radiant heat and also to obtain a heat-reflecting surface between the burner and the first few feet of fire tube, the tube was lined with fireclay for about three to four feet in from the burner. The flame itself extended beyond this lining into the unprotected part of the fire tube where the ash particles remained unfused, falling out in the form of powder on the comparatively cold inner surface of the fire tube. Fig. 2 shows the method of firing adopted.

The boiler has remained in constant operation since November, 1928. Removal of the flue ash by hand with the help of scrapers occupies two or three hours, which represents the only time at which the boiler is not operating. In this method of operation a battery of seven boilers if equipped for coal-dust firing would require the services of one attendant and two men for ash drawing, or a total of five men in 24 hours. With mechanical means for removing the flue ash the men engaged for removing it by hand would be unnecessary.

One great advantage of this method of firing is the small wear of the individual parts. Up to the present the nozzles of the experimental boiler have been exchanged once only. These nozzles are merely specially formed pipe ends about 8 in. long, which can be made at small cost in every mine workshop. At the same time, it is recommended that these be made of good heat-resisting material. The fireclay protection in the fire tube must be renewed about every ten weeks.

All other parts, even after six months' operation, show no sign of wear, and the air preheater in particular shows no sign incrustation. The performance of the boiler, as at present operated, without mechanical removal of the flue ash, is between 6 to 6.2 lb. of steam per sq. ft. of heating surface per hour, with a minimum of 5.2 to 5.4 lb.

The original article gives data of a test made with the double-fire-tube boiler and the above method of firing. (*World Power*, vol. 12, no. 70, Oct., 1929, pp. 374–377, 1 fig., *d*)

The Wignall-Wollaston Producer Boiler

AT A RECENT exhibition of smoke-abatement appliances held in Manchester, England, the steam for some of the exhibits was supplied by a Wignall boiler fitted with a Wollaston gas-producer furnace made by Hartley & Sugden, Ltd., of Halifax. From a sectional view of the boiler, Fig. 3, it will be seen that it is a combination of the vertical and horizontal types. The lower portion is similar to that of most vertical boilers, but the upper part consists of a horizontal steam and water drum fitted with smoke tubes, the two portions of the boiler being connected by means of an insulated smoke casing. The products of combustion on leaving the firebox are led by means of this smoke casing to the lower bank of tubes, through which they pass to the front of the boiler, then back through the upper bank of tubes to the flue.

The arrangement combines the spacious firebox of the vertical boiler with the long flue travel of the horizontal boiler, which, it is claimed, enables the maximum of heat to be abstracted from the products of combustion. The smoke tubes are entirely submerged and there are no tube ends in the firebox. The upper drum gives a larger steam space than is found in most vertical boilers and, incidentally, a larger surface area of water, while the head room required is less. Accessibility for cleaning is obtained by manholes, mudholes, and tube doors, by means of which tube renewals can be effected easily.

The height of the boiler is 7 ft. 3 in. overall, and the horizontal drum is 4 ft. 9 in. long by 4 ft. in diameter, the heating surface 135 sq. ft. and the grate area 7 sq. ft. The working pressure is 100 lb. per sq. in., and the maximum evaporation is 925 lb. per hour from and at 212 deg. fahr.

The furnace portion of the plant is a water-luted gas producer,

the refractory crown of which is virtually a bunsen burner. It is fan-blown, the air discharge from the fan being divided into two streams, primary and secondary, which, by means of simple valves, can be regulated as required. The primary air, saturated to a degree corresponding with an average temperature of 59 deg. cent., is regulated to make a high quality of producer gas in the upper part of the producer, while the secondary air, passing round the annulus in the hot refractory crown, is pre-

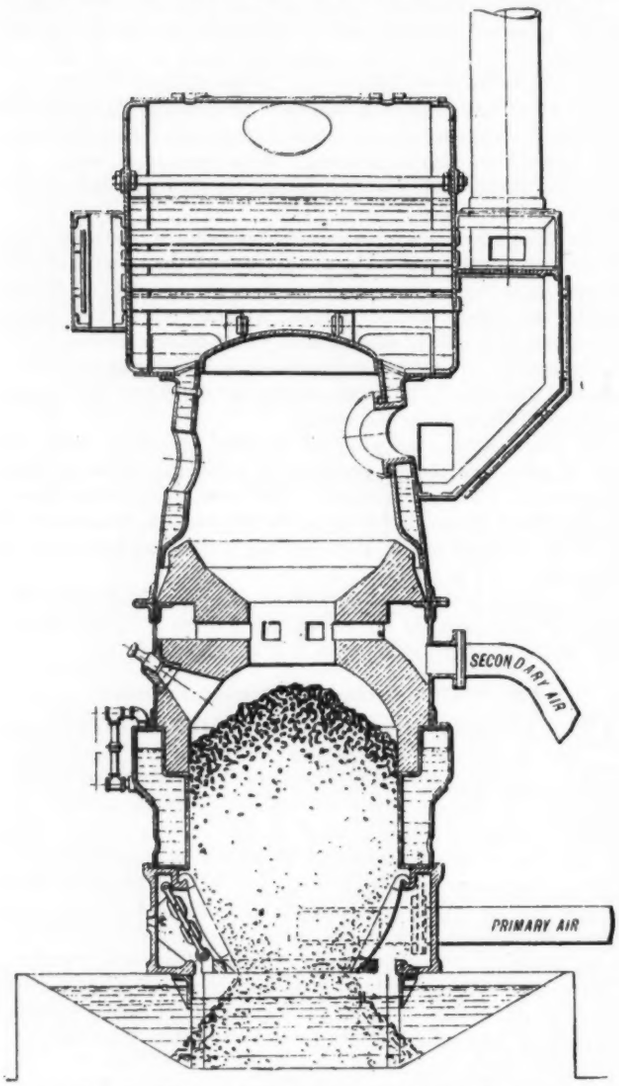


FIG. 3 WIGNALL-WOLLASTON PRODUCER BOILER

heated prior to joining the gas at the bunsen throat, where ignition takes place and a clear, hot flame is produced.

The low-pressure steam for the saturation of the blast is obtained from the water jacket around the producer, and the makers claim that the jacket is so proportioned that, at all loads, it provides the correct amount of steam necessary for saturation purposes. This jacket also acts as a water-cooled metallic wall which prevents the formation of clinker when using fuels containing fusible ash, or if any clinker does form, it is prevented from adhering to the walls. It further usefully employs the radiant heat of the oxidation zone of the producer. This water jacket is fed by gravity through a Royle water-level regulator, and is provided with a safety valve which blows off at 5 lb. per sq. in.

The grate is a recently patented modification of the Mond grate, and the bars, instead of lying against a rigid base, rest upon a steel ring suspended by chains at three points. By the insertion of a poker, this ring can be swung very slightly, thus imparting a motion to the bars which is sufficient to bring the ash down uniformly. The ash zone is maintained up to a level at, or nearly corresponding with, the top of the bars, so that the losses of heat in combustible and sensible temperature in ash are very small.

At the Manchester Smoke Abatement Exhibition, the fuel used was cinders separated from the Manchester town's refuse, and it contained quantities of broken glass, broken brick, and other foreign materials. One analysis showed: Moisture, 5.18 per cent.; ash, 27.43 per cent; sulphur, 1.56 per cent; combustible, 65.83 per cent; and the calorific value was 9185 B.t.u. per lb. For this class of fuel the Wollaston producer appears to be particularly suitable, since its large capacity enables larger volumes to be fed at a time, while the removal of ash is very infrequent. The efficiency of the boiler is claimed to be over 80 per cent, and the percentage of CO_2 in the chimney gas 17 1/2 when burning the fuel mentioned above. (*The Engineer*, vol. 148, no. 3858, Dec. 20, 1929, p. 672, 1 fig., *d*)

Alternative Methods of Power Generation

THIS discussion is based on the presidential address recently delivered by S. B. Donkin to the Association of Supervising Electrical Engineers, Great Britain, on the subject of "Future Methods of Power Generation."

The most popular method of power generation today is by combustion of fuel, particularly coal. Water power comes next. Among the more ambitious projects in connection with the latter is a scheme for utilizing the difference in level between the valley of the Jordan and the Mediterranean, which is of the order of 1000 ft., the idea being to construct an intake at Haifa and convey the water over the watershed either by siphonic action or by pumping to a station near Beisan. It is estimated that about 500,000 kw. could be obtained in this way.

Wind power is yet another alternative to coal, and has of course been employed in more or less primitive forms from time immemorial. Recently, it has been utilized to a considerable extent, especially in Denmark and certain parts of Germany, for generating electricity, and has also been the subject of investigation by the Institute of Agricultural Engineering in this country. It suffers even more than tidal power from irregularity of supply, but even when the cost of the storage equipment is taken into account, the capital expenditure necessary for its development is much less. This being so, it is strange that its use has not been more extended, though the explanation probably is that the alternatives, coal and oil, are more generally known and have been more extensively tried.

Mr. Donkin also draws attention to the suggestion of M. H. Barjot that the latent heat of ice might be utilized, in localities where extremely low temperatures exist, by pumping water at 32 deg. fahr., or over, from under the surface ice of a lake or a river into a boiler, and there employing it to evaporate some fluid which is insoluble in water, such as certain volatile hydrocarbons. The result would be that the fluid would boil and cause a corresponding amount of water to freeze. The vapor obtained by the boiling would be utilized to operate a turbine, the exhaust from which would be passed to a condenser containing frozen brine, thus causing the hydrocarbon to be liquefied, so that it could be used indefinitely. This scheme does not seem to have been tried in practice.

To sum up the whole matter, engineering experience warns up against stating that anything is impossible. In the majority of the schemes reviewed by Mr. Donkin, however, it is economic

rather than engineering difficulties that will prevent their development. There are doubtless, even in this country, many water powers that could be harnessed, but to do so and to bring the energy generated to places where it could be utilized would cost more than to erect a fuel-operated station of equal capacity. The same applies with even greater force to such schemes as those for harnessing the Mediterranean and to most of those for utilizing tidal power, while in other cases the intermittency of the power generated renders the whole idea impracticable, unless very costly storage systems are provided, when it becomes uneconomic. Perhaps the sole exception to this rule is that of wind power, but even then the amount of energy that can be generated in this way is generally so small as to be unattractive. While, therefore, there is no reason why such schemes should not be investigated and even tried, the better road to economy seems to be to make every effort to use our existing sources in the best possible way. (*Engineering*, vol. 128, no. 3331, Nov. 15, 1929, p. 612, *g*)

Employment of Heat Radiation as a Means of Reducing the First Cost of Boiler Plants

THE author discusses the subject of employment of radiant-type boilers, and refers extensively to American practice. He begins by a recapitulation of the theory of heat radiation generally and of radiant-type boilers in particular, and uses extensively the methods first proposed by Münzinger in his work (in German), "Calculation of Water-Tube Boilers" (Berlin, 1929). Münzinger developed his formula from the more theoretical work of Wohlenberg, Morrow, and Lindseth, published in two papers presented before The American Society of Mechanical Engineers.

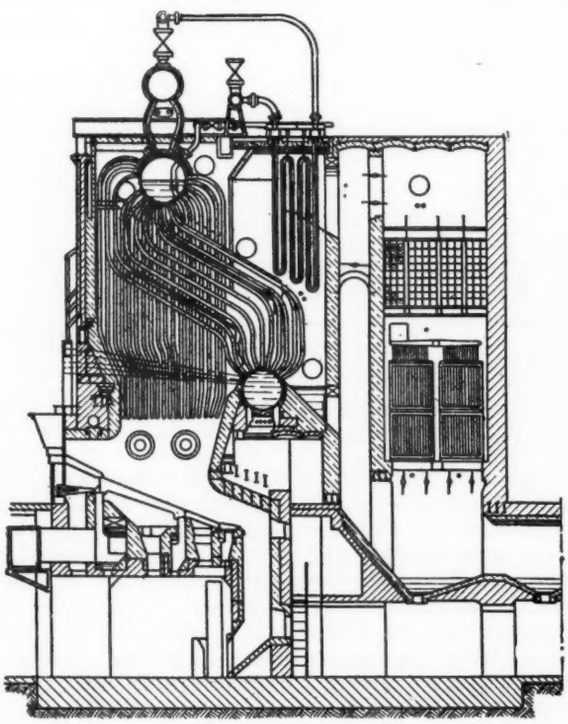


FIG. 4 RADIANT-TYPE BOILER IN THE MUNICIPAL CENTRAL STATION ON ENGERTH STREET, VIENNA

The theoretical part of the article cannot be abstracted here because of lack of space.

All radiant-type boilers may be divided according to the author into three groups: 1, Special types of water-tube boilers; 2, fire-tube boilers with pulverized-coal firing but without an ignition chamber; and 3, locomotive boilers (not discussed in the present article). Special radiant-type water-tube boilers are being built in Germany by a number of concerns. One of these is the American Lopulco radiant boiler. The Hanomag Company

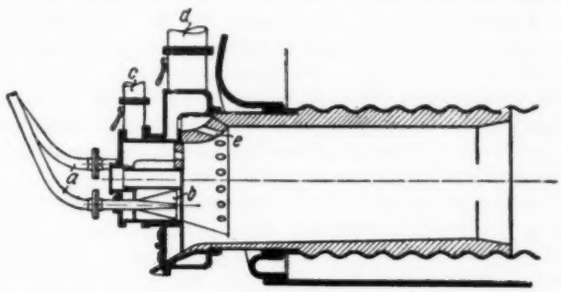


FIG. 5 BURNER OF THE KOHLENSTAUB CO. FOR FIRE-TUBE BOILERS WITHOUT IGNITION CHAMBERS

has also built a number of them and the author gives several illustrations of this type. In a boiler built by that company for installation at the Fibre Textile Works, Waldhof, the following data apply:

Steam pressure	45 atmos. (640 lb. per sq. in.) gage
Steam temperature	420 deg. cent. (788 deg. fahr.)
Grate area	12.6 sq. m. (135.6 sq. ft.)
Normal output	10,500 kg. (23,100 lb.) per hr.
Heating area	180 sq. m. (1936.8 sq. ft.)

Between the long upper drum and the short lower one there is in the rear portion of the boiler a comparatively small nest of tubes serving as contact heating surface. All the rest of the heating surface acts as radiation heating surface and is divided between the front wall and the side walls of the furnace. After leaving the boiler the combustion gases go through the superheater and economizer into the smokestack. The tubes of the side walls and front wall are expanded into a collector box into which water flows down from the upper drum through pipes not exposed to heat. It is particularly important to notice that the tubes carrying most of the load open into the upper drum at the water level or above it, the purpose of this being to obtain a light load on the evaporating surfaces.

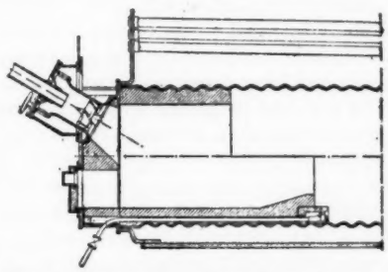


FIG. 6 BURNER FOR FIRE-TUBE BOILER WITH PULVERIZED-COAL FIRING AS INSTALLED ON THE STEAMER "DONAU" OF THE NORTH GERMAN LLOYD

The boiler shown in Fig. 4 and installed in a central station in Vienna is equipped with a Pluto grate. With an operating pressure of 22 atmos. (312.8 lb. per sq. in.) gage and a heating area of 450 sq. m. (4842 sq. ft.) it is designed for a normal steam generation of 30 tons (66,000 lb.) per hr., corresponding to 66.7 kg. per sq. m. (13.64 lb. per sq. ft.) per hr. and a peak load of 50 tons or 110,000 lb. per hr. Here again of practical importance is claimed to be the fact that the tubes carrying most of the load open into the upper drum at the plane of the lowest water level. The path of travel of the gases is from the boiler heating surfaces to the superheater, water preheater and air preheater.

Another illustration, on the other hand, shows a boiler of the ordinary type with the fire chamber extensively equipped with radiant tubes. Of particular interest here is the absence of a suspended roof. Instead, a nest of tubes has been installed and

over this there is only a thin layer of firebrick and another of insulating material. Another significant feature is that the tubes for the side-wall cooling open not into a collector box but directly into the upper boiler. This construction provides on the one hand a liberal cross-section for conducting away the steam, and hence a smaller resistance than usual. On the other hand, the upward movement of the steam bubbles accelerates the water circulation also in the part of the chamber which is not directly heated, and extends this acceleration of circulation up to the point where the tubes enter into the upper boiler. This construction is a good example of how boilers of conventional design can be converted into radiant-type boilers.

The author proceeds next to the discussion of fire-tube boilers using pulverized-coal firing but without an ignition chamber. The impetus to the design of such boilers was given first by the desire to utilize better than previously the numerous fire-tube boilers still operating in industrial plants, and also by the effort to utilize the advantages of pulverized-coal firing for marine use. In such arrangements it is particularly important to secure a quick and reliable ignition of the powdered coal in order to avoid certain losses and dangers. To achieve this it is necessary to have first a thorough distribution of the coal dust in the combustion air and then a powerful turbulence in the flame—if necessary—by admission of secondary air.

A good example of this type of burner is that of the Kohlenstaub G.m.b.H. (Pulverized Coal Co.) of Aix-la-Chapelle, shown in Fig. 5. Here the supply of pulverized coal is effected through pipe *a* which ends in a cruciform nozzle *b* consisting of two long narrow slots at right angles to each other. There are three such nozzles in the burner chamber, and part of the primary air is admitted through pipe *c* so as to surround the latter. The remainder of the combustion air is highly preheated in pipe *d* and secondary air nozzle *e*. This latter is set crosswise to the axis of the burner and produces turbulence in the flame. This type of firing has been in use for a considerable period of time with both lignite and bituminous coal dust, and has given efficiencies up to 70 per cent in boilers without economizers or superheaters. Fig. 6 shows a section through the fire box of the Berlin Kohlenstaubfeuerung G.m.b.H. (Pulverized Fuel Firing Co.) boiler, installed among other places on the steamer *Donau* of the North German Lloyd. In this case the powdered coal with its carrying air is introduced into the burner through a central pipe and mixed in the chamber of the combustion housing with the secondary air. Simultaneously the mixture is set to rotating by means of a system of guide vanes. A peculiar feature of this system of firing lies in the fact that the burner is set with its axis pointing sharply downward. This arrangement has been selected in order to make it possible to remove the slag from the lower part of the fire tube, which is about 2 meters long, in as fluid a state as possible.

The radiant-type boiler as compared with the ordinary boiler can carry a much higher average load per unit of heating area, while the maximum load from the point of view of safety is lower. If radiant-type boilers are used, much smaller heating surfaces are sufficient, particularly if liberal use is made of air preheating. Because of this, boilers of the radiant type are not much more expensive to build than those of the ordinary type, particularly as practically standard parts can be used in their construction. The fact that the radiant type of boiler is not extensively used today is due to several causes, one of which is that the type has not yet been completely standardized, and another that experimental work is usually included in the price of the boiler. The author expects that when this period of development has been completed a different picture will be presented. (Dr. of Engrg. Wilhelm Schultes in *Die Wärme*, vol. 52, no. 49, Dec. 7, 1929, pp. 939–944, 12 figs., *d*)

SPECIAL MACHINERY

An Accurate Cold-Heading Machine

A COLD-HEADING machine has recently been brought out in England (Windsor Works, Redditch, designed by Edward White) for the purpose of making such objects as rivets, screw blanks, etc. It is said to work with an accuracy to the nearest 0.002 in. This result is attained by the provision of fine adjustments in many parts of the machine, such as the wire feed, the wire stop, the transfer slide travel, etc. For such high-grade work as the machine is intended to perform it is necessary to use a solid die, as an opening die must leave a mark or ridge around the head. Hence the operations of cutting off the wire from the stock and heading it up are performed in two separate dies, and the wire has to be transferred from one die to the other.

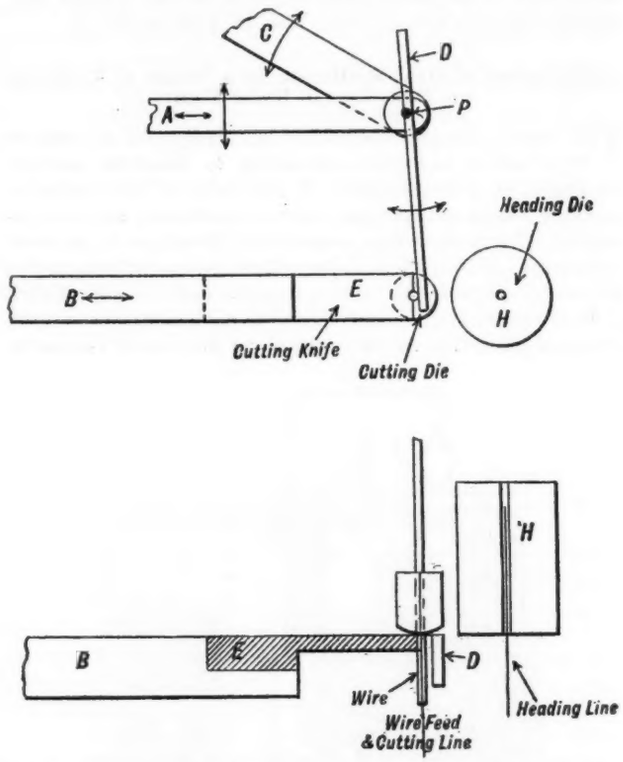


FIG. 7 CUTTING-OFF MECHANISM IN A BRITISH ACCURATE COLD-HEADING MACHINE

In the wire-feed mechanism the most interesting feature is that dealing with the adjustment of the length of feed. As this has to be more accurate than is attainable with one ratchet wheel, the angular movement of the pawl-carrying arm is made adjustable regardless of the throw of the eccentric. As a final protection against inexact length of the wire feed there is a dead stop against which the stock is pushed. This stop, illustrated in the original article, has a micrometer adjustment, and if an excess in wire is fed forward a slipping takes place in the feed rolls.

The length of wire for each piece is cut off by a simple shearing action against the mouth of the die. The knife is plainly shown in Fig. 7. A semicircular notch is made in the cutting edge of the knife *E*, which is utilized to hold the cut-off piece of wire while it is being transferred to the heading die *H*. It is of course necessary to hold the piece in this notch during its transference, and this is effected by the finger *D*.

In action the wire is fed forward against the stop (not shown

in Fig. 7), the knife advances, cuts off the piece, and presses it against the finger *D*. The whole motion—*A*, *B*, *C*, *D*, *E*—then moves across to the center line of the heading die *H*. The heading punch then comes up and starts to push the piece into the heading die. Immediately afterward the whole transfer mechanism recedes, the finger *D* passing over the top of the wire ready to receive a fresh piece of wire. The heading die continues its stroke, and forms the head to make the finished piece. The lifting of the finger *D* over the top of the wire is effected during this part of the stroke by a taper on the die punch.

As the main slide and punch return, the finished piece is ejected from the die by a knocker-out pin which works backward and forward in the back of the die, and is actuated by the slide itself. The various mechanisms are so interconnected that it is practically impossible to jam the machine, but an added precaution is provided into the form of a spring catch in the drive of the cut-off cam, which gives, should any undue pressure occur on the transfer finger or cut-off knife.

The moving parts of the machine run on bronze slides of large area, arranged on the outside of the machine so that they are readily accessible and can be properly adjusted. As a consequence the machine runs very smoothly and without whip. The normal running speed is 180 strokes per minute, but it can be safely run up to 260 strokes per minute. The machine is made in six sizes, for wire from 0.032 in. up to 0.19 in., and for blanks up to 4⅝ in. long. (*The Engineer*, vol. 148, no. 3856. Dec. 6, 1929, pp. 616–617, 6 figs., *d*)

SPECIAL PROCESSES (See Engineering Materials: Metal Hard-Facing)

THERMODYNAMICS

Heat Transfer in the Condensation of Saturated an Superheated Steam in a Horizontal Tube

THE authors of the present article carried out sometime ago a series of tests on heat transmission in the condensation of steam in a vertical pipe. The advantage of testing heat transfer in a vertical pipe is that the conditions of condensation inside of the pipe are symmetrical with respect to the axis, which is not necessarily the case in a horizontal tube. On the other hand, however, horizontal tubes are of much greater importance technically, and tests of heat transfer in such a case were considered to be important. The means for these tests were provided jointly by the Community of German Science and the German Society of Engineers.

The present article describes the method of carrying out the tests, the arrangement of the thermocouples employed, and the correction of errors. This part cannot be abstracted, because of lack of space. It may be stated that 146 tests were carried out, in all of which, in addition to the distribution of temperature in the pipe, the heat transfer was determined calorimetrically. This permitted plotting the heat acquired by the cooling water per hour per square meter of tube-wall surface and the entrance velocity of the steam.

Substantially the same laws govern the phenomena here as in the case of the vertical tube: namely, the heat transfer increases with the increase in temperature difference between steam and wall and with the increase of velocity of flow of steam. For purposes of comparison the various data have been plotted in Figs. 9 and 10—the solid lines for horizontal tubes and the broken ones for vertical tubes. The fact that in a horizontal tube more heat is given up when the condensation temperature is higher (i.e., lower wall temperature) than is the case in the

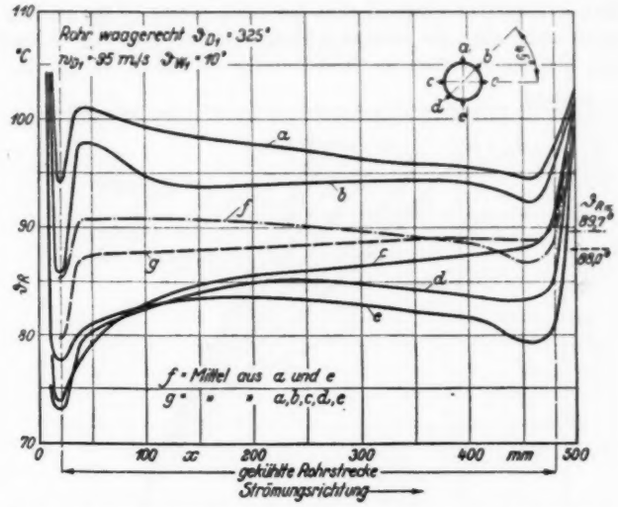


FIG. 8 TEMPERATURE DISTRIBUTION IN VERTICAL AND HORIZONTAL CONDENSER TUBES

(Upper left-hand angle: Horizontal tube
Steam temperature at the beginning = 325 deg. cent.
Velocity of flow of steam at the beginning = 95 m. per sec.
Temperature of cooling water at the beginning = 10 deg. cent.
Center bottom: *f* = average of *a* and *e*
g = average of *a*, *b*, *c*, *d*, *e*
ϑ_{Rm} = average wall temperature
ϑ_R = wall temperature
Gekühlte Rohrstrecke = cooled part of the tube
Strömungsrichtung = direction of flow.)

vertical tube, is obviously due to the fact that the water film in the case of the horizontal tube is thinner in a part of the tube. It is not quite so clear why the solid and broken lines intersect, which means that more heat is given up at a higher wall temperature in the vertical tube than in the horizontal tube. To explain this the author uses the data of Fig. 8. When the wall temperature ϑ_{Rm} approaches the saturation temperature, the sheaf of temperature curves for the various jacket curves shifts upward and the peak curve runs over the saturation limit at a time when the average wall temperature is still considerably lower. It may therefore happen that the steam at the top of the tube no longer condenses. The condensing surface is not reduced thereby, but is limited more and more to the lower part of the tube, which is covered with water of condensation and is therefore not as effective as the upper part of the tube. It may therefore happen that with the same average wall temperature in the neighborhood of the saturation temperature the vertical tube will be more efficient than the horizontal tube.

The authors show further that the "quality factor of heat transfer" β is greater in the horizontal tube when the amount of heat supplied Q_E is greater and the wall temperature lower than is the case with the vertical tube; but if Q_E is small—or even large—and the wall temperature at the same time is high, then β is smaller for the horizontal than for the vertical tube.

Calculation of Water Film. An attempt is made to calculate the thickness and velocity of flow of the water film from the data plotted in Fig. 8. To do this the water-cooled surface F of the tube is divided into a certain number, say, eighty, equal parts, each of which extends over one-tenth of the length of the tube and one-eighth of its circumference. Then in a unit of time a certain amount of heat Q_n passes through each surface element:

$$Q_n = \alpha w \frac{F}{80} (\vartheta_R - \vartheta_W) \quad [1]$$

The value of ϑ_R (temperature of the wall of the tube) for each surface element is given in Fig. 8. In the absence of other

data it is further assumed that the temperature of the cooling water along the tube rises in a linear relation from ϑ_{W1} to ϑ_{W2} and that furthermore the heat-transfer coefficient α_W for the

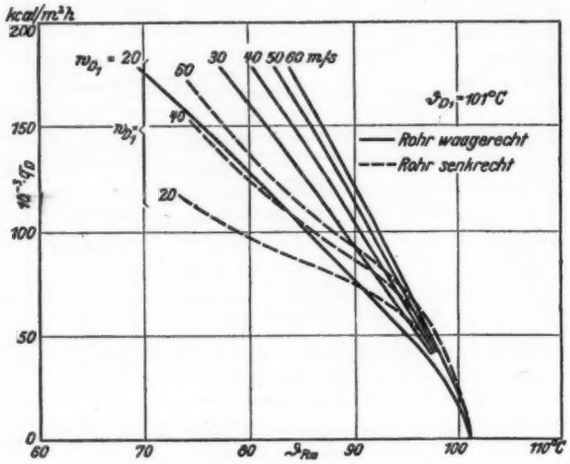


Fig. 9 Heat Given Up by Saturated Steam

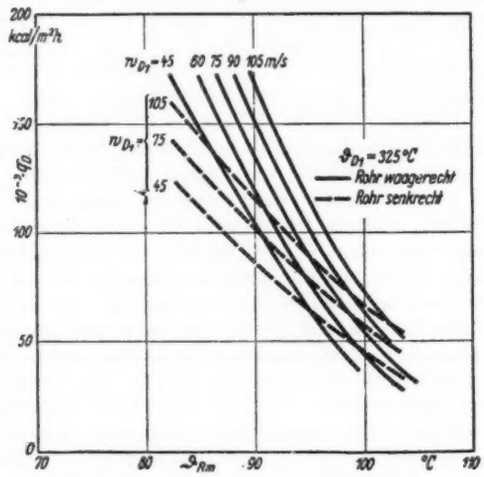


Fig. 10 Heat Given Up by Superheated Steam

FIGS. 9 AND 10 HEAT LOSS DEPENDING ON THE AVERAGE TUBE-WALL TEMPERATURE AND VELOCITY OF STEAM FLOW

(ϑ_{D1} = temperature of steam at the beginning of the tube
ϑ_{Rm} = average tube-wall temperature
w_{D1} = velocity of flow of steam at the beginning of the tube
Solid lines = horizontal tube
Broken lines = vertical tube.)

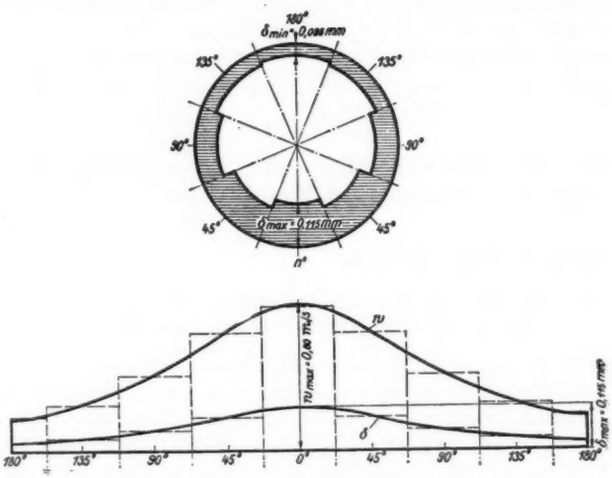
cooling-water side is the same throughout. This gives the following equation:

$$Q = \sum_{n=1}^{n=80} Q_n = \alpha_W \frac{F}{80} \sum_{n=1}^{n=80} (\vartheta_N - \vartheta_W) \quad \ldots\ldots [2]$$

where Q is the total heat taken up by the cooling water in a unit of time. If we calculate α_W from Equation [2] and insert its value into Equation [1], then the value of Q_n for each element of surface will be obtained. Since furthermore this amount of heat is transmitted to the wall surface through the film of water, the following equation will hold provided the drop of temperature through the film of water follows the linear law as assumed by Nusselt:

$$Q_n = \lambda_n \frac{F}{80} \frac{\vartheta_n - \vartheta_R}{\vartheta} \quad \ldots\ldots\ldots\ldots [3]$$

where ϑ is the thickness of the film of water in the nth surface element, λ_n the coefficient of heat conductivity of water at the temperature $(\vartheta_n + \vartheta_R)/2$. Because of the disturbance at the end caused by the flow of cooling water, ϑ has been calculated only for $X < 450$ mm. (see Fig. 8), and the part of the curve for the last 50 mm. (say, 2 in.) has been extrapolated. The values thus calculated for the thickness of the water film at the terminal cross-section are given in Figs. 11 and 12 with a magnification of thirty times as compared with the diameter. The thickness of the film of water lies between 0.026 mm. at the top and 0.115 mm. at the bottom of the tube. If now one calculates—as has been done by Nusselt—the acceleration produced in the film of water by the flow of steam (using experimental data obtained by Eberle where gravity acceleration may be neglected because of the greater steam acceleration) the average velocity of flow of the film of water at each spot will be obtained. In Fig. 12 these values are plotted for the terminal part of the tube where measurements were taken. It is possible to calculate only the amount of water of condensation G_K which comes out of the test tube. The present experimenters have obtained the value of 6.47 kg. per hr. and have calculated from the heat given up to the cooling water a value of 6.56 kg. per hr. This close agreement of results speaks well for the correctness of the assump-



FIGS. 11 AND 12 THICKNESS ϑ AND VELOCITY w OF THE WATER FILM
(Amount of condensation G_K in kg. per hr. calculated from water film, 6.47; determined experimentally, 6.56.)

tions based on the Nusselt water-film theory, as well as for the admissibility of the simplifying assumptions made in the present article.

The authors believe that these tests have clarified our knowledge as to the processes of heat exchange in steam condensation. Our knowledge of the phenomena, however, is not complete by any means. [M. Jakob, S. Erk, and H. Eck (communication from the Reich Physico-Technical Institution) in a paper before the Committee for Heat Research of the Verein Deutscher Ingenieure in Hanover, April 20, 1929; abstracted through *Zeitschrift des Vereines deutscher Ingenieure*, vol. 73, no. 42, Oct. 19, 1929, pp. 1517–1520, 10 figs., *eA*]

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Instruments and Apparatus

Preliminary Draft of Part 17—Determination of the Viscosity of Liquids

The Main Committee on Power Test Codes takes pleasure in presenting to the members of the Society for criticism and comment Part 17—"Determination of the Viscosity of Liquids" of "Instruments and Apparatus." The Individual Committee which has developed this draft consists of Messrs. C. F. Hirshfeld, Chairman, W. A. Carter, Secretary, C. M. Allen, E. G. Bailey, L. J. Briggs, C. R. Cary, J. D. Davis, R. E. Dillon, F. M. Farmer, J. B. Grumbein, W. H. Kenerson, E. S. Lee, O. Monnett, S. A. Moss, R. J. S. Pigott, E. B. Ricketts, and J. T. Ward.

The "Instruments and Apparatus" Section will consist of twenty-two parts dealing with the following subjects: (1) General Considerations,[1] (2) Pressure Measurement (6 chapters),[2] (3) Temperature Measurement (12 chapters),[3] (4) Head Measurement, (5) Measurement of Quantity of Materials, (6) Electrical Measurements,[4] (7) Mechanical Power, (8) Measurement of Indicated Horsepower, (9) Heat of Combustion, (10) Chemical Composition (5 chapters), (11) Determination of Quality of Steam, (12) Time Measurements, (13) Speed Measurement,[5] (14) Mechanical Measurements, (15) Surface Area, (16) Density, (17) Determination of Viscosity of Liquids, (18) Humidity, (19) Concentration of Dilute Solutions, (20) Smoke, (21) Leakage Measurements (2 chapters),[6] and (22) Hydraulic Power Plants.

Complete copies of the draft which is published here in abstract may be obtained from the Society's headquarters. The Individual Committee, the Main Committee, and the Society will welcome suggestions for corrections or additions to this draft from those who are especially interested in the subject. These comments should be addressed to the Chairman of the Committee, in care of The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y.

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[1] This part was published in the February, 1923, issue of MECHANICAL ENGINEERING.

[2] Chapter 1 of Part 2, on Barometers, was published in the November, 1927, issue of MECHANICAL ENGINEERING.

Chapter 6 of Part 2, on Tables, Multipliers, and Standards for Barometers, Mercury and Water Columns, and Pressure Measurements, was published in the July, 1928, issue of MECHANICAL ENGINEERING.

[3] Chapter 1 of Part 3, General, was published in the December, 1925, issue of MECHANICAL ENGINEERING.

Chapter 6 of Part 3, on Glass Thermometers, was published in the April and May, 1926, issues of MECHANICAL ENGINEERING.

Chapter 7 of Part 3, on Pressure-Gage Thermometers, was published in the October, 1928, issue of MECHANICAL ENGINEERING.

[4] This part was published in the December, 1928, issue of MECHANICAL ENGINEERING.

[5] This part was published in the April, 1929, issue of MECHANICAL ENGINEERING.

[6] Chapter 1 of Part 21, on Condenser Leakage Tests, was published in the November, 1925, issue of MECHANICAL ENGINEERING.

I—GENERAL

1 Viscosity is a property of homogenous fluids which causes them to offer frictional resistance to motion. In Fig. 1 [not reproduced here], for example, let A be the area perpendicular to the paper of a portion of the liquid $BCDE$. This area, which is distant Δx from an equal parallel area having a velocity V, is moved with a uniform velocity of $V + \Delta V$ by the force F'.

2 It has been observed experimentally that under these conditions

$$\frac{F'}{A} = \text{Constant}\left(\frac{\Delta V}{\Delta x}\right) = \mu\left(\frac{\Delta V}{\Delta x}\right)$$

where the constant μ is known as the coefficient of viscosity, or absolute viscosity, or more simply as the viscosity. It may be noted that

$$\frac{F'}{A} = \text{shearing stress}$$

while

$$\frac{\Delta V}{\Delta x} = \text{rate of shear}$$

Hence

$$\mu = \frac{F'/A}{\Delta V/\Delta x} \quad \ldots\ldots [1]$$

so that viscosity may be defined as the ratio of shearing stress to rate of shear.

3 The numerical value of viscosity depends upon the system of units used. In the c.g.s. system the unit of viscosity is known as the "poise." Thus from the above, a liquid has a viscosity of 1 poise when a force of 1 dyne is required to move an area of 1 square centimeter, within the liquid, past another parallel area 1 centimeter away, at a velocity of 1 centimeter per second.

4 The poise is the most commonly used unit at present, but for convenience in converting this unit to other systems in use, the factors in Table 1 may be used.

TABLE 1 UNITS OF VISCOSITY AND CONVERSION FACTORS

Absolute Viscosity:		
1 dyne-second per square centimeter	=	1 poise
1 kilogram-second per square meter	=	98.07 poises
1 pound-second per square foot	=	14.882 poises
1 pound-second per square inch	=	68,947 poises
Kinematic Viscosity:		
$\frac{\text{1 dyne-second per square centimeter}}{\text{grams per cubic centimeter}}$	=	$1\ \frac{\text{cm.}^2}{\text{sec.}}$
$\frac{\text{1 kilogram-second per square meter}}{\text{kilograms per cubic meter}/g}$	=	$10{,}000\ \frac{\text{cm.}^2}{\text{sec.}}$
$\frac{\text{1 poundal-second per square foot}}{\text{pounds per cubic foot}}$	=	$929.03\ \frac{\text{cm.}^2}{\text{sec.}}$
$\frac{\text{1 pound-second per square inch}}{\text{slugs per cubic inch}}$	=	$77.419\ \frac{\text{cm.}^2}{\text{sec.}}$

5 In efflux instruments for measuring viscosity (known as "viscometers" or "viscosimeters") in which the driving pressure is a head of the liquid, the ratio of viscosity to density is an important quantity. It is known as the "kinematic viscosity" of the liquid,

and in the c.g.s. system its numerical value is the viscosity in poises divided by the density in grams per cubic centimeter. For convenience in converting this unit to other systems in use, the factors in Table 1 may be used.

6 In the simple case illustrated in Fig. 1, there is a uniform rate of shear of $\Delta V/\Delta x$ radians per second throughout the liquid between the two areas considered. In less simple cases this may not be true. For example, in the very common case of streamline or non-turbulent flow of liquids through a tube of diameter d, the rate of shear is equal to $16\overline{V}_1 r/d^2$, where $\overline{V}_1$ is the average velocity of flow and r is the distance from the axis to the point under consideration. It will be seen that the rate of shear is variable, the mean value over the entire cross-section of the tube being $16\overline{V}_1/3d$. However, if the rate of shear varies from point to point in a simple viscous liquid, the shearing stress also varies, maintaining the ratio of shearing stress to rate of shear constant. This constant ratio μ, which depends upon the nature of the liquid, is independent of the rate of shear and of variations in rate of shear throughout the liquid. Hence the determination of μ is not confined to any one type of instrument. As will be seen later, two of the most common types of viscometers are the capillary tube and the rotation instrument with two coaxial cylinders. Variations of velocity and of rate of shear in these two types of instruments are illustrated in Fig. 2 [not reproduced here], where

l = length of capillary
p = difference in pressure between ends of capillary
Wr = turning moment applied to one cylinder
H = wetted height of cylinder.

II—Available Instruments

7 A great variety of forms of apparatus have been used *experimentally*, such as falling or rolling spheres and torsional pendulums with the bob immersed in the liquid to be tested, and with which either the retardation or a constant deflection is observed. But the great majority of *industrial instruments* in general use are of the *efflux type*, in which measurement is made of the discharge through a short tube or capillary during a measured interval of time. For these instruments, if a head of the liquid under test furnishes the driving pressure, the relation between the viscosity and the time of flow, t, is given by the equation

$$\text{Kinematic viscosity} = \frac{\mu}{\rho} = At - \frac{B}{t} \quad \ldots\ldots\ldots [2]$$

where t is the time in seconds for a volume of discharge which is standard for each type of instrument, ρ is the density in grams per cubic centimeter, and A and B are instrument constants which depend upon the dimensions of the instrument. (See Table 6.)

8 Figs. 3 and 10 show some technical efflux viscometers commonly used in the physical testing of lubricating oils.

III—Procedure to Be Followed—General

9 To make a viscosity determination, clean and dry the container and pass the oil or other liquid to be tested through a 100-mesh wire strainer. Heat the oil, outside the viscometer, to slightly above the temperature at which the viscosity is to be determined, and pour it into the container.

10 Tests of viscosity[7] must be made at the temperatures at which the information is desired, since the change of viscosity with the temperature cannot be predicted with any degree of accuracy. It is therefore necessary to select an instrument having a constant-temperature bath which can be heated by means available at the laboratory or installation in question. Any field instrument, or one without a bath which is used at room temperature, can give only rough and approximate results, but may be very useful in determining whether two liquids have the same or different viscosities.

11 Some viscometer baths are so arranged that they may be heated by steam, gas, or electricity, and the better commercial instruments are supplied with a reliable thermostat which will hold the bath temperature to within 0.1 deg. fahr. (0.06 deg. cent.) or less of the desired temperature. Since a difference in temperature of 0.1 deg. fahr. may make a difference of 1.0 per cent in viscosity, the importance of accurate temperature control is evident.

IV—Precautions in Taking Readings—General

12 In order to obtain accurate results, care must be taken to use only viscometers and auxiliary instruments which have been accurately standardized. Stop watches and thermometers are necessary with every type of viscometer. Also flasks and hydrometers are usually needed. For very heavy oils, or for great accuracy with lighter oils, a picnometer is necessary. A little practice enables one to use a stop watch without serious error, and disagreements between laboratories are usually due to differences in dimensions of viscometers or to inadequate temperature control.

13 The U. S. Bureau of Standards is prepared to furnish oils of known Saybolt or known absolute viscosity for calibrating viscometers.

V—Types of Viscometers

14 In the further treatment of viscometers the various types will be treated separately, giving for each: description with advantages and disadvantages; range and accuracy; procedure to be followed; precautions in taking readings; corrections; and calibration.

[7] When viscosity has been determined at more than one temperature, gross errors may sometimes be detected by the use of a viscosity-temperature diagram such as that of N. McCoull (*Lubrication*, published by the Texas Co., p. 5, June, 1921) or of W. H. Herschel *Oil and Gas Journal*, Tulsa, Okla., Dec. 2, 1926). See Fig. 4.

The Emmet Mercury-Vapor Process

AN INSTALLATION for using this process has recently been made in the Meadows Station of the Hartford Electric Light Co. The mercury turbine in this case is rated at 10,000 kw. The previous installation in the Dutch Point Station of the same company had a maximum capacity of about 2000 kw. This larger equipment was completed in November, 1928, and was run for about three weeks. Trouble then developed in one of the boiler tubes due to improper installation, and this is now being corrected. It is stated that while the unit ran, it saved the company $800 a day in fuel alone. Except in the boiler there was no trouble and no observable deterioration. There was no erosion in the mercury turbine. The furnace showed no deterioration, and the heating surface was easily kept clean.

Plans for the further development of this process include carrying considerable degrees of overload by the simple increase of firing, accompanied by increase of pressure in the mercury vapor. By using a larger generator and a little different arrangement of heating surface, a pressure of 100 lb. gage will give over 40 per cent increase of output from the mercury turbine, and, owing to the higher temperature limit, the fuel efficiency will be better notwithstanding the greater congestion of the apparatus and of the heating surfaces.—W. L. R. Emmet, Consulting Engineer, General Electric Company, in a paper delivered at the World Engineering Congress in Tokyo, Japan, October–November, 1929; abstracted through the *General Electric Review*, vol. 32, no. 11, November, 1929, pp. 619–621, 4 figs.

Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later on in the proper place in the Code.

The Boiler Code Committee has received and considered suggestions for Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers. This movement is a result of the inadequacy of both riveted and forge-welded construction for such drums or shells for boilers to operate at from 900 lb. to 1500 lb., unless the diameters are kept down to impracticable limits. On the other hand, recently, refinements in the application of fusion welding have made practical the welding of drums and shells of plate thicknesses up to 3 in. or more, and vessels constructed in this manner have been successfully used in large numbers in connection with petroleum-refinery equipment. The proposed specifications which are now under the joint consideration of the American Welding Society and the Boiler Code Committee are submitted below for criticism and comment thereon from any one interested. Discussions of the proposed specifications should be mailed to the Secretary of the Boiler Code Committee, 29 West 39th Street, New York, N. Y., in order that they may be presented to the Committee for consideration.

Proposed Specifications

1 Drums or shells of power boilers may be welded by the fusion welding process when materials suitable for welding are used in accordance with Pars. S-5 to S-17, or S-264 to S-279, of Section II of the Code, and provided the following requirements are fulfilled.

2 *Test Plates for Longitudinal Joints.* Two (2) sets of test plates from steel of the same heat as the drum plates, prepared for welding, shall be attached to the shell being welded as in Fig. 1, one set on each end of one longitudinal seam, so that the edges to be welded in the test plates are a continuation of and duplication of the corresponding edges of the longitudinal seam in the shell. Weld metal shall be deposited in the test plates continuously with the weld metal deposited in the longitudinal joint of the shell.

NOTE: Recommendations have been made that as an alternative, the test specimen be allowed to be cut out of the welded longitudinal joint at any point, and the hole thus made welded up afterward if the tests of the specimen show the vessel to be acceptable.

3 *Test Plates for Circumferential Joints.* When test plates are welded for the longitudinal joints, none need be furnished for circumferential joints in the same vessel. Where a drum has circumferential joints and no longitudinal joint, a set of test plates of the same material as the shell shall be welded in the same way as the circumferential joint.

See also note under Par. 2.

4 *Stress Relieving.* The complete welded structure or such welded parts separately as may be later assembled by means other than welding, shall be heated uniformly to at least 1100 deg. fahr. The structure shall be brought slowly up to the specified temperature and held at that temperature for a period of at least one hour per inch of thickness, and shall be allowed to cool slowly in a still atmosphere. The test plates shall be subjected to the above stress-relieving operation either attached to or placed within the parent vessel.

5 *Test Specimens.* The inspector shall select one of the two welded test plates, from which the coupons for tension, impact, and bend tests and for macro and micro examinations shall be removed as shown in Fig. 2.

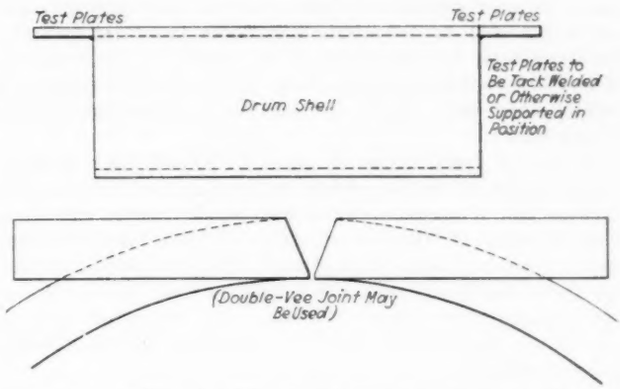
Test Plates
Test Plates
Drum Shell
Test Plates to Be Tack Welded or Otherwise Supported in Position
(Double-Vee Joint May Be Used)

FIG. 1 SKETCH SHOWING TEST PLATES ATTACHED TO SHELL

6 *Tension Tests.* The tension specimen shall be transverse to the welded joint, and shall be the full thickness of the welded plate after the outer and inner surfaces of the weld have been machined to a plane surface flush with the plate. When the capacity of the available testing machine does not permit of testing a specimen of the full thickness of the welded plate, the specimen may be cut with a thin saw into as many portions of the thickness as necessary, each of which shall meet the requirements.

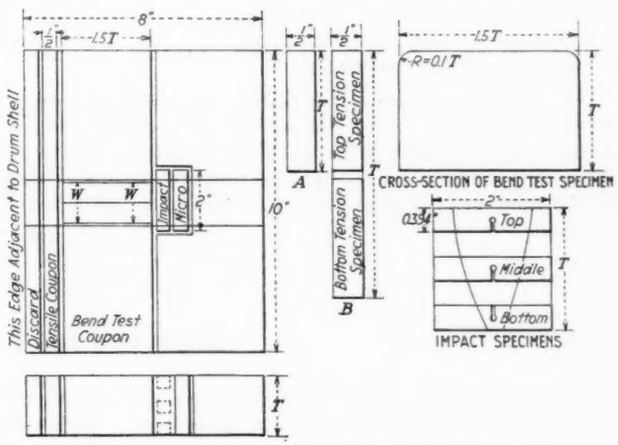

FIG. 2 TEST SPECIMENS FROM WELDED TEST PLATE

A = cross-section through tension specimen.
B = cross-section through tension specimen parted in two.
T = thickness of plate
W = gage length on bend-test specimen.

Each tension specimen should fail in the boiler plate, but if failure occurs in the weld metal or along the line of fusion between weld metal and the plate, then the tensile strength shall not be less than the minimum of the specified tensile range of the plate used.

7 *Bend Tests.* The bend-test specimen shall be transverse to the welded joint of the full thickness of the plate and shall be of rectangular cross-section with width $1^1/_2$ times the thickness of the plate. When the capacity of the available testing machine does not permit of testing a specimen of the full thickness of the welded plate, the specimen may be cut with a thin saw into as many portions of the thickness as necessary, each of which shall meet the requirements. The inside and outside surfaces of the weld shall be machined to a plane surface flush with the plate. The edges of this surface shall be rounded to a radius equal to 10 per cent of the thickness of the plate. The specimen shall then be bent cold under free bending conditions until the least elongation between any two points within and across the weld on the outside fibers of the bend-test specimen is 30 per cent, with the width of any surface cracks deducted. No surface crack shall be longer than 10 per cent of the specimen's width, when the elongation of the outside fibers has reached 10 per cent.

8 *Impact Tests.* Three coupons for impact tests shall be taken transverse to the welded joint and prepared so that the cross-section of the specimen through which fracture will occur shall contain: (1) the bottom surface, (2) the middle section, and (3) the top surface of the weld. The notch in the bottom specimen shall be opposite the bottom surface, and in the top specimen, opposite the top surface. The minimum value of the impact test shall be 20 ft-lb., standard A.S.S.T. Charpy impact specimen.

9 *Chemical Analyses.* Drillings from the weld metal representing an average sample shall conform to the following requirements:

Manganese	0.30–0.60 per cent
Phosphorus	not over 0.04 per cent
Sulphur	not over 0.045 per cent
Nitrogen as iron nitride	not over 0.020 per cent

The nitride content shall be determined by the modified Allen method of the Bureau of Standards (Scientific Paper No. 457, U. S. Bureau of Standards).

NOTE: A majority of those who have been consulted consider this test unnecessary.

10 *Macro and Micro Examinations.* Macrographs prepared from coupons taken across the welded joints and etched with suitable reagents shall show no laps, excessive porosity, nor incomplete fusion. Micrographs of polished specimens taken in the same manner shall show no evidence of coarse-grained material.

NOTE: A majority of those who have been consulted consider this test unnecessary.

11 *Retests.* Should the bend or impact tests fail to meet the requirements by more than 25 per cent, retests shall be allowed on specimens cut from the second welded test plate. These retests shall comply with the requirements. Should any of the original tests fail to meet the requirements by 25 per cent or more, no retests shall be allowed. If the tension test fails to meet the requirements, additional tension tests shall be allowed on two specimens cut from the second test plate and both of these shall meet the requirement.

12 *Non-Destructive Tests of Vessel.* The welded joints of the annealed structure shall be explored by an approved recording non-destructive test, such as an electrical or magnetic fissure detector or X-ray apparatus, which will determine quantitatively the size of a defect.

NOTE: A majority of those who have been consulted consider this test unnecessary.

13 *Fatigue Tests.* The annealed vessel shall be subjected to 10,000 cycles of pressure, each cycle varying from zero to $1^1/_2$ times the working pressure. These cycles of pressure should preferably be applied at the rate of 10 to 12 per minute.

The welded joints shall then be again explored by the approved non-destructive test apparatus. The second set of readings shall show that no change in the welded joints has occurred during the fatigue test.

NOTE: Objections have been raised against this test by those who consider it unnecessary or capable of dangerously affecting the structure.

14 *Holes.* No holes shall be located in a welded joint. When holes in the plate are located near a welded joint, the minimum distance between the edge of a hole and the edge of a joint shall be equal to the thickness of the plate, when the plate thickness is from 1 in. to 2 in. With plates less than 1 in. thick, this minimum distance shall be 1 in. With plates over 2 in. in thickness, the minimum distance shall be 2 in.

15 *Allowable Working Stress.* When constructed under the above provisions, the maximum unit working stress of a welded joint may be taken as one-fifth of 80 per cent (16 per cent) of the minimum of the specified tensile range of the plate used.

NOTE: Criticisms have been received which claim that the maximum unit working stress allowed should be from 90 to 100 per cent of the minimum of the specified tensile range.

Riveted and Welded Bridges

MANY structures, bridges in particular, are subjected through frequently repeated application of loads to a more or less important constant loading. A precise determination of the phenomena of fatigue and aging is extremely difficult to carry out on existing structures. The Federal Railroad Central Administration in Berlin carried out duration tests on an iron foot bridge and on welded experimental beams. One of the purposes of these tests was to determine how a bridge behaves generally when under constant loading, and next it was desired to determine the difference between riveted and welded constructions as affected by recent developments in the art of welding. Because of lack of space, only some of the conclusions can be given here.

In the first place, it has been found that if it be assumed in order to make practical comparisons possible that the riveted and welded superstructure is to act as a railroad bridge, and if it be further assumed that trains will follow over the bridge at one-half intervals, and that while the train is passing over the bridge the maximum load will be reached only once, then the breaking duration stress applied during test is equivalent to something like thirteen years of operation in the case of the riveted bridge, and only $1^1/_2$ years in the case of the welded bridge. It must be clearly understood that these figures are based on comparatively short duration tests and must not be used as a basis of comparison of the two methods of construction. Nevertheless the tests appear to indicate that in future dynamic investigations of bridges in service an increase of natural frequency in the course of the test may be taken as indicating an increase in strength, i.e., good state of preservation of the structure.—Dr. of Engrg. R. Bernhard, Berlin, in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 73, no. 47, Nov. 23, 1929, pp. 1675–1680, 33 figs.

Engineering and Industrial Standardization

Standardization of Transmission Roller Chains, Sprockets, and Cutters

ROLLER-CHAIN standardization was initiated in 1917 when definite recommendations for the pitches, roller diameters, pin diameters, side-plate thicknesses, and chain widths were developed by a Committee of the A.S.M.E. in conjunction with the Roller Chain Division of the Society of Automotive Engineers. This report was expanded, and together with specifications for sprockets and sprocket cutters was approved by the Society in 1921. Study of the proposed standard was continued jointly by a Committee of the A.S.M.E. and the S.A.E., and later the Sprocket Committee of the American Gear Manufacturers' Association was invited to cooperate in this activity. Then in 1924 the Joint Committee was reorganized into a Sectional Committee under the procedure of the American Standards Association with the S.A.E., the A.G.M.A., and the A.S.M.E. as joint sponsors. This Committee's task was to review the standards then existing and to formulate a proposal for adoption as an American Standard that would be applicable to uses other than automative drives.

To Sub-Committee No. 1, G. M. Bartlett, Chairman, was assigned the division of the project dealing with roller chains. The proposal of this Committee has been completed and has received the approval of the Sectional Committee. It is now before the three sponsors for approval and transmission to the American Standards Association. In preparing its report Sub-Committee No. 1 made a careful study of roller chains, sprockets, and cutters and their use in current practice. Contacts were maintained with roller-chain interests abroad to secure, so far as possible, international uniformity in roller-chain standardization. The proposed American Standard for Transmission Roller Chains, Sprockets, and Cutters includes in addition to dimensions and nomenclature, illustrations for design, types, parts, and assembly.

Accordingly, as one step in the A.S.M.E. procedure for approval, there are reproduced herewith a typical table of standard dimensions and illustrations for the information of our readers. Those who are especially interested in this subject to the extent of making a critical review may secure a copy of the complete report by addressing C. B. LePage, Assistant Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y.

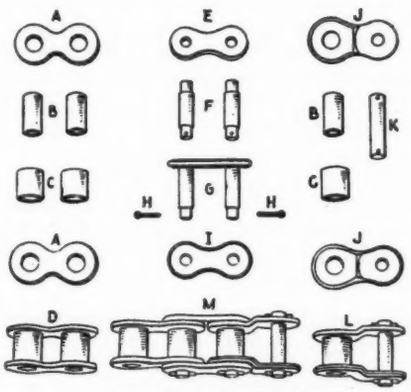

FIG. 1—ROLLER CHAIN PARTS

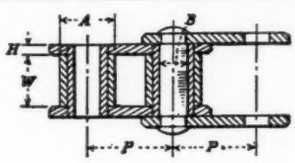

FIG. 2—LINK ASSEMBLY

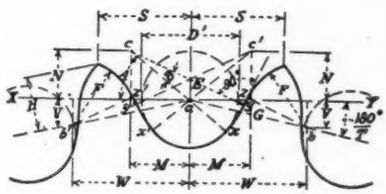

FIG. 7—DESIGN OF STANDARD SPROCKET TEETH

TABLE 1—GENERAL CHAIN DIMENSIONS

		Standard Series						Extra Heavy Series
Pitch *P*	Roller Diameter *A*	Width *W*	Pin Diameter *B*	Thickness of Inside Plate *H*	Test Load, Lb.	Measuring Load, Lb.	Standard Chain No.	Thickness of Inside Plate *H*
3/8	0.200	3/16	0.141	0.050	555	17	35N	.....
1/2	5/16	5/16	0.156	0.060	740	25	40	.....
5/8	0.400	3/8	0.200	0.080	1,400	44	50	.....
3/4	13/32	1/2	0.234	0.094	2,018	63	60	0.125
1	1/2	5/8	0.312	0.125	3,820	119	80	0.156
1 1/4	5/8	5/8	0.375	0.156	5,626	176	100	0.187
1 1/2	3/4	3/4	0.437	0.187	7,760	242	120	0.219
1 3/4	7/8	1	0.500	0.219	10,220	319	140	0.250
2	1	1	0.562	0.250	13,008	406	160	0.281
2 1/2	1 1/4	1 1/4	0.781	0.312	25,340	792	200	0.375
3	1 5/8	1 1/2	0.937	0.375	36,634	1,145	240	0.500

Trade Standards of the Compressed Air Society

THE fourth edition of a pamphlet giving the trade standards adopted by The Compressed Air Society has just been published. New material included comprises a new formula for use in air-compressor testing, this being accurate for higher water columns than that previously used; further suggestions in connection with the installation and operation of air compressors; caution against the use of old boilers or tanks as air receivers; suggestion for handling very cold "cooling water" so as to prevent condensation and undue wear on the air cylinders; and another illustration of an air-cleaning device. Copies may be obtained upon application to C. H. Rohrbach, Secretary of The Compressed Air Society, 90 West Street, New York. Price, fifty cents per copy.

Safety Code for Grandstands

THE American Standards Association has been requested to consider the formulation of a standard safety code for steel grandstands. This request to the A.S.A. has been made by manufacturers interested in material required for the construction of such grandstands, with the suggestion that the code could apply to both permanent and portable structures. It has been found that these structures oftentimes are erected without any attention being given to their strength and durability.

The Conference Table

THIS Department is intended to afford individual members of the Society an opportunity to exchange experience and information with other members. It is to be understood, however, that questions which should properly be referred to a consulting engineer will not be handled here.

Inquiries will be welcomed at Society headquarters, where they will be referred to representatives of the various Professional Divisions of the Society for consideration. Replies are solicited from all members having experience with the questions indicated. Replies should be as brief as possible. Among those who have consented to assist in this work are the following:

ARCHIBALD BLACK, Aeronautic Division
A. L. KIMBALL, Applied Mechanics Division
H. W. BROOKS, Fuels Division
R. L. DAUGHERTY, Hydraulic Division
WM. W. MACON, Iron and Steel Division
JAMES A. HALL, Machine-Shop Practice Division
CHARLES W. BEESE, Management Division
G. E. HAGEMANN, Materials Handling Division
J. L. WALSH, National Defense Division
L. H. MORRISON, Oil and Gas Power Division
F. M. GIBSON and W. M. KEENAN, Power Division
W. R. ECKERT, Petroleum Division
MARION B. RICHARDSON, Railroad Division
WINFIELD S. HUSON, Printing Industries Division
JAMES W. COX, JR., Textile Division
WM. BRAID WHITE, Wood Industries Division

Miscellaneous

Bending a Heavy I-Beam

M-3 It is proposed to bend a 9-in. I-beam of heavy section to a radius of 11 ft. 3 in. What methods are recommended to accomplish this without destroying the shape of the web of the beam?

a Beams of this description have been bent successfully by the use of a bulldozer, which consists of two movable supports upon which the beam is mounted, and a pneumatic ram which hammers the beam between its supports. The beams are bent cold in order to prevent deformation, and are slowly hammered into their final shape by gradually widening the distance between supports. At the same time the beam is shifted along the supports. A die on the end of the ram is formed so that it fits into the side of the I-beam, following its contour exactly except for a slight amount of clearance to allow it to move freely in and out of the space between the flanges.

A $^3/_4$-in. plate is bolted to each side of the die so that it hammers against the flanges of the I-beam, but not against the web. This counteracts a tendency of the flanges to cave in at the edge of the die.

Beams bent in this manner are free from distortion. They are used as segments of the rim of a large rope sheave, the segments being riveted together. After assembly the sheaves are tested, and are held to an accuracy of $^1/_8$ in. at the web.

Ten-inch I-beams are used, and the radii of the sheaves vary from 6 ft. to 8 ft. 9 in., although larger radii would be easier to obtain without deformation of the web. (M. Unterberger, Mechanical Engineer, Champion Shoe Machinery Co., St. Louis, Mo.)

b There are standard machines built for the purpose of bending heavy I-beams. A machine manufactured by the company with which the writer is connected provides for adjustment by a handwheel so as to give more or less bend to the beam, which may be bent with the web in either a horizontal or a vertical position. The shape of the web is not destroyed by the operation. If but one or a few beams are to be bent so that the purchase of a machine is not warranted, any medium-sized structural shop could take care of the work. (A. L. Bechtel, Vice-President and Chief Engineer, Cleveland Punch and Shear Works Co., Cleveland, Ohio.)

Questions to Which Answers Are Solicited

Use of Pulverized Coal for Firing Shaft Lime Kilns

F-14 Has a direct-fired pulverized-coal system ever been used to fire shaft lime kilns? If so, give brief description, results obtained, difficulties encountered, and data on operation.

Machinery Control

M-1 Why is not more use being made in mechanical engineering of control of machinery by perforated strips?

Conveying Sand Hydraulically

M-10 It is planned to convey sand from a washer to a height of 20 ft. above the washer by means of water injected at high velocity through a nozzle into a 5-in. pipe. Does this arrangement seem feasible, or will the quantity of water to be disposed of offset the advantages gained by the elimination of mechanical apparatus?

Etching Numbers on Thickness Gages

M-13 What is an inexpensive method of etching numbers on thickness gages? A rubber stamp dipped in acid has been tried, but with acid strong enough to etch the impression clearly, the rubber stamp is corroded.

Causes and Remedies for Cinder Cuts in Boiler Flues of Locomotives

R-4 What are the causes and satisfactory remedies for cinder cuts in the flues of steam locomotives? They occur both inside the firebox above the firebricks at the boiler head and also in the front end or smokebox.

Counterbalancing Freight Locomotives

R-5 The counterbalance of a heavy freight engine, class L2, has been found 390 lb. too light. The only place where more weight can be added is at the ends of the counterbalance and close to the center of the wheel. How can the required weight be calculated?

Manufacture of "Wood Flour"

WI-1 Is information available on the manufacture of "wood flour" from sawdust and shavings? Where may one inspect a plant manufacturing this product?

Correspondence

Boiler-Metal Embrittlement

TO THE EDITOR:

The discussion by Dr. McAdam in the January issue of MECHANICAL ENGINEERING, in which he reviews Mr. H. F. Rech's recent paper on boiler-metal embrittlement, seems to indicate that differences of opinion are more apparent than real, and that the various investigators are essentially in agreement on these fundamental considerations:

1 That deterioration of the boiler plate is due to a number of factors
2 That the term "embrittlement" is not properly descriptive of the phenomenon, but continues in use for the reason that interested parties all know what it means.

The real controversy rages around the importance of the several factors which are contributing causes. Among the proponents of the theories featuring stress, whether cyclic or continuous, whether due to design or the faulty methods of fabrication, each one urges to the point of insistence that his particular hobby-theory factor is most important. They cannot all be individually right, but in combination they probably are. Still the fact remains that, in spite of the really fine research work being done along these lines, correction of these stress factors is necessarily a matter of the future, and will in all probability require a period of years for development, for the test of actual service, and for general acceptance. Further, it is not at all improbable that continued research may develop still other factors or contributing causes.

The advocates of proper water conditions in the boiler appear to be more generous in their attitude. While freely admitting the importance—perhaps even the major importance—of other factors, they emphasize the fact that the condition of the boiler water is also an important factor, and further that it is the *only controllable factor* as far as present installations are concerned. This seems to me to be the matter of greatest immediate interest to the rank and file of operators, as being the only precautionary step they can take right now.

Ordinary common sense indicates the propriety of applying the maximum possible measure of protection to the vast investment in existing plants, based on our present information, while at the same time continuing the investigation of all possible contributing causes, and following up with proved corrective measures. If one were suffering from a number of ailments he would scarcely refrain from curing one, merely because he could not cure them all simultaneously.

Mr. Rech's paper certainly corroborates in a marked degree the generally accepted belief that unfavorable condition of the boiler water is an extremely important contributing factor in causing so-called embrittlement. It is rare indeed that there is opportunity to make such a striking comparison as in the case of the two plants at Jackson, where every condition was substantially duplicated, except only the water treatment.

Such evidence, together with Mr. F. G. Straub's published statement[1] that in all the instances of embrittlement which have been investigated not a single one has occurred with boiler waters which met the A.S.M.E. recommendation, lends strong support to the theory that water control alone is an effective solution. Entire elimination of objectionable stresses, if it proves practicable to achieve such a result, may similarly accomplish the same result regardless of water conditions, but it will require a long period of operation to demonstrate this and establish confidence in its effectiveness. During such period it is safe to wager that operators will continue to watch their water conditions anyway, so this alternate theory may never be conclusively proved.

H. L. WOOLFENDEN.[2]

Detroit, Mich.

[1] "Embrittlement Prevention in Steam Boilers," *Power Plant Engineering*, Feb. 1, 1929.

Fundamentals of Management

TO THE EDITOR:

I am very glad to note that in answer to my recent letter, Mr. Alford has presented his viewpoint of the problem of securing the practical fundamentals of scientific management. The presentation of both of our viewpoints in the December issue of MECHANICAL ENGINEERING affords a comparison of our objects and the means we are employing to secure the fundamentals on which control over industrial operations can be based.

Mr. Alford has looked at industry as a whole, and his papers entitled "Laws of Manufacturing Management" and "A Basis for Evaluating Manufacturing Operation" reflect this viewpoint. An examination of the first paper reveals that it is a general statement of principles which are recognized in present industrial organizations. To be of practical worth, the principles would require quantitative measurements of their degree of application.

His second paper is a painstaking statistical study of the results of productivity in industry. A productivity scale on the basis of a thousand man-hours overlooks many factors which were presented in the discussion following the presentation of this paper, but nevertheless it is an important rating of industry. To attempt to apply any data secured from this study to a specific case, however, is entirely opposed to a principle of relativity which indicates that the results of a particular plant can be evaluated only on the basis of the standards for that plant as they happen to be at a given time.

In my analysis of the operating viewpoint, I have viewed the problem of securing the true fundamentals of scientific management as one of securing the operating policies and the standards for these policies for a specific plant. There are outstanding standards for such a plant based on its facilities which may not be found in any other plant in the same industry or any industry. These standards are economic guides and from this viewpoint may be considered as the laws of management for the plant.

Mr. Alford has understood that the fundamentals of this new technique are the ratings of the results on the basis of the standards of these operating policies. These ratings supply the measurement of management which is important for the management spirit and investment work. The fundamentals by this technique would be:

1 Secure the essential policies for control over operations
2 Set standards based on capacity for these policies
3 Rearrange standards for coordination of the policies
4 Rate results of operations by the standards
5 Organize for continual improvement of standards.

These rules are in accordance with the definition of "fundamental" in a paper on "The Operating Point of View in Industry" which I have prepared for later presentation, viz.:

> *Fundamental:* A basis; rules serving for the groundwork of a system.

GEORGE G. BERGER.[3]

New York, N. Y.

[2] District Manager, Neckar Water Softener Corporation. Mem. A.S.M.E.

[3] Industrial Engineer. Mem. A.S.M.E.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields. The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers, and Proceedings of

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Contributions of interest to the profession are solicited. Communications should be addressed to the Editor.

BY-LAW: The Society shall not be responsible for statements or opinions advanced in papers or . . . . printed in its publications (B2, Par. 3).

The April Issue

THE April issue of MECHANICAL ENGINEERING will be devoted to the Fiftieth Anniversary of The American Society of Mechanical Engineers. Special features of historical and biographical significance have been planned, and all regular departments will be omitted. The history of the Society and the lives of its presidents and honorary members will be reviewed briefly, and the progress of fifty years in the field of mechanical engineering will be reported by the Professional Divisions, their representatives, and special writers.

Mathematical Tools

IN THE Engineering Survey Section of this issue of MECHANICAL ENGINEERING is published an abstract of a paper by O. Ackermann describing a cathode-ray oscillograph. An interesting feature of the paper is that in the calculation of this apparatus, use was made of a principle of the relativity theory in accordance with which energy has inertia. While this is extremely interesting, the importance of the fact that the use of this principle has produced a simplified but still correct formula must not be exaggerated. It is important because it places in the hands of the physicist a new mathematical tool. On the other hand, it does not in any way prove the correctness of the portion of the Einstein theory employed. As a matter of fact, there are a number of mathematical conceptions which are successfully used in calculation without thereby establishing the independent physical existence of the concept so used. Thus, since the days of Charles P. Steinmetz extensive use has been made of so-called imaginary quantities in the calculation of alternating-current electric circuits—i.e., quantities multiplied by the square root of minus one—and though while purely imaginary, their use produces real and correct results.

In thermodynamics use is made of four-dimensional equations without thereby establishing the fact that four-dimensional space has actual existence. While such reservations should properly be made in connection with the method employed in Mr. Ackermann's paper, it may be expected that if ultimately further cases are found where principles of relativity are employed under conditions to which they would apply in accordance with all the other parts of that theory, then such employment may be instrumental in bringing about a greater readiness to accept the theory on the part of physicists and even engineers. Once more, if this happens, it will be demonstrated that, no matter how abstruse and apparently supertheoretical an investigation may be, it will give practical results if correctly employed.

A generation ago a professor of mathematics is said to have boasted that the beauty of a calculus which he had discovered lay in the fact that it would never be of any practical use; such an attitude of mind is going to be more and more difficult to maintain. It is said that when Einstein published his theory of relativity he stated that there were not more than twelve people who could understand his work. Who knows but what the day may soon come when the electric washing machine will be designed by using relativity formulas? If we believe Mr. Ackermann, it can already be tested on an apparatus, the design of which involves at least one of its essential elements.

Research in the Steel Industry

TIME was when such "high-brow" activities as research were anything but popular in the steel industry. Its leaders in the past mostly came up from the ranks and were justly proud of it. They saw their enterprises grow from comparatively modest beginnings into huge aggregations of men and machinery, and they could not see why they should bother with crystal lattices or atomic structures when they had enough trouble handling labor, railroads, politicians, and buyers. There were some concerns, of course, which had a different attitude toward research, but they were chiefly makers of special steels, dealing in pounds where the big fellows thought in carloads. However, an entirely new state of affairs has come about in the last three years.

The United States Steel Corporation was the first to go into research on a thoroughly large scale. After this the development of continuous wide-strip rolling by the Columbia Steel Company, later taken over and amplified by the American Rolling Mill Company, showed the importance of patented processes in modern steel manufacturing, an importance which only a few years before would have been contemptuously denied by the production men. Since then developments have come thick and fast. The A. M. Byers Company has introduced a new process of manufacturing wrought iron which promises to upset the previously existing equilibrium between wrought iron and steel. The Republic Iron and Steel Company has taken over the Johnson patents on the manufacture of electrically welded tubing, thereby infusing new life into the welded-pipe business, which seemed to be on its last legs.

A group of companies in this country have taken out licenses under the Krupp patents for the surface hardening of steel by nitriding, a process based on reactions previously unknown to the steel people and hence requiring some intensive research.

So great has become the value of research in the steel industry and so clearly recognized its importance, that at the time of the formation of the merger represented by the Republic Steel Corporation, it was announced that as part of the new organization there would be formed a Republic Research Corporation led by

one of the biggest men in the organization and given ample sums for carrying on research work on a huge scale.

Early research activities in the steel industry date back many years. In 1860, Robert Woolston Hunt, former president and honorary member of the A.S.M.E., established at the Cambria Iron Works the first analytical laboratory to be maintained in America by an iron and steel company.

It is significant also that the canny Scotch ironmaster Andrew Carnegie recognized the value of chemical analysis for controlling the operation of the blast furnace. "Andy," as he was fondly known to his associates, for all of his wealth was the last man to spend money on unnecessary refinements. He realized, however, that by buying ores to a definite specification he did not have to pay high prices for famous ore brands, and in his autobiography he dryly remarks that the analysis permitted him to buy the most suitable ores at quite moderate prices. What the analyst's simple outfit did in the early days of steel making in America, the elaborate X-ray and spectrograph apparatus of the modern laboratory are beginning to do today.

To the engineer this tendency toward making research an integral part of steel manufacture is of enormous significance, because it will have two effects: first, in making the product conform to specifications in a previously unobtainable manner; and second, in helping to produce materials capable of withstanding stresses to an extent undreamed of today. Just as an example of what has already been achieved, it may be stated that in certain steel-mill operations, carbon specifications are given as, say, 0.47 to 0.49, and melts have been rejected because the carbon varied one-hundredth of one per cent from the specification. Ten years ago, a melt that varied no more than five-hundredths of one per cent would have been considered a perfectly satisfactory one.

"Mass Production"

"MASS PRODUCTION" is an expression which at one time had a very definite meaning. Lately, however, and with its use by laymen, its special technical significance has been obscured by a cloud of opprobrious connotations that have gathered around it. "Efficiency" is another term which has fallen upon the evil days of too popular and too indefinite use. The word "engineer" is being also endangered, as also is "research." "Standardization," which means so much that is worth while and important to the entire world, has come to mean, in the popular mind, a senseless conformity, a stagnation of progress, and a suppression of initiative and individuality. So has the meaning of "mass production" been perverted.

Perhaps engineers would be wiser, and at the same time avoid the misuse and misunderstanding of their words and ideas, if they were to follow the example of, let us say, the biologists, and develop a terminology so foreign to the mother tongue that only the elect could understand the jargon. Some fearful and wonderful names can be invented by the adoption of a method involving the experimenter's surname, a few Greek or Latin roots, and a number of suffixes and prefixes, the entire combination being written as one word.

But the way to salvation is not to be found through such subterfuges, because the simpler scheme of adopting homely English words is much to be preferred, even if the engineer does have one meaning and the layman another, and even if it gives the layman a false sense of understanding when the words are familiar in other connotations. This is what is wrong with "mass production."

Whenever certain critics of the industrial age find themselves in a sufficiently heroic and crusading mood they attack mass production. It is synonymous with what is most typical and most opprobrious in America and the machine age. It brings out the passionate denouncement of the degradation of the handicrafts and the craftsman, of thwarted creative effort, of lost interest and pride in work and skill, of the monotonous repetition of tasks, few and simple, performed with machine-like precision, by slaves doomed to monotonous routine. It raises the cry of horror at the products thus produced in the mass, millions of things all so smugly alike, so ugly, so trivial, so unromantic.

"Roadrails, pig lead, firewood, ironware, and cheap tin trays."

Without rushing to the defense of a system whose effectiveness in promoting human welfare is beyond need of demonstration, and whose methods are as easily perverted in unworthy causes as are those of any other, would it not be well, once in a while, to remind ourselves that mass production does not mean these things to an engineer.

Mass production—well named, no doubt, at birth—has grown so that it transcends the limiting connotation of the word "mass." Another term for it might be "continuous production," for after all, the technique which is designated, while applicable chiefly to production in large quantities, is only employed when there is a continuity of manufacture and assembly which takes advantage of the principles of flow. The current is deep, swift, and strong, between well-defined banks, without stagnant inlets or whirlpools of sluggish backwater. The method involves the strictest coordination of all elements to the accomplishment of the desired end with the minimum total cost in materials, time, and labor. While certain mechanical elements, such as a production chain for manufacture or assembly, may assist materially in the coordination because they can be so accurately timed, the chain, the machines, are not the brains, but merely the physical members of a synthesis of intelligence and machinery.

"Continuous production" may not be a better term than "mass production." In fact, the word "continuous" may convey the idea of tedium. But at least it is descriptive, and as yet has not been confounded by the critics of our very fruitful machine civilization.

A New Meaning of Saturation in the Automobile Industry

FEAR of saturation in the automobile industry originally grew out of the idea that there were in the country only a comparatively limited number of people who could afford to buy automobiles; and that as soon as these persons had purchased their machines the demand would be restricted to cars required for replacements and for the growing generation, or, according to various estimates, to from one-quarter to one-half of the automobiles actually being produced.

It is not necessary to discuss here the various circumstances which have apparently made the fear of saturation through lack of customers who can afford to buy automobiles practically groundless The number of cars in use has been steadily increasing, and because of the increasing wealth of the country the length of time during which purchasers have been satisfied to keep their cars and not replace them by more modern and better designs has been becoming shorter and shorter. From the point of view of sales, the used motor car which a dealer has to take over when selling a new one is much more difficult to dispose of than a new machine, even though all agree that there are still as a rule plenty of transportation possibilities in the trade-in.

Of late, however, another conception of saturation has been growing up, namely, the saturation of streets and highways. After all, there is no advantage in owning a motor car if with it one cannot get to the place he wishes to get, or if the getting there is so slow or so uncomfortable that public conveyances or taxicabs become preferable.

The congestion on the public highways, and particularly on the busy streets in towns, has been growing steadily worse as the number of cars has been increasing, until the point has been reached where certain streets are so clogged as to make rapid transit entirely impossible and any kind of transit very trying, nerve racking, and unsafe during business hours generally.

What is more, only a comparatively insignificant proportion of automobile users can afford to have a chauffeur, which makes the matter of parking an extremely important one. In this respect, however, cities are rapidly approaching a dilemma, and that is, if parking is permitted, it so restricts the width of the street as to make the flow of traffic in the necessary volume impossible. The only way out is to sacrifice the privilege of parking or eventually to restrict it. All cities have begun by restricting it, and quite recently the police commissioner of New York City found that enforcing the regulations as to limited time of parking took an enormous share of the time of the traffic police and brought about very indifferent results as far as assisting traffic was concerned.

In Chicago, parking has been completely prohibited in the "Loop," which contains the big hotels, department stores, banks, etc. The New York City police commissioner recommends abolishing all parking below 61st Street, which means the entire business section of the city. Naturally, as a means of relief, automobile hotels have been recommended, that is, buildings remodeled for the purpose of parking automobiles during the day. It is estimated that in New York City, for example, provision would have to be made for 40,000 cars. This is all very well as far as it goes, but garage parking means a substantial outlay in fees when it has to be resorted to several times in the course of a day. For example, a salesman wishing to use an automobile in his business would have to pay a fee for each customer on whom he called, which obviously would make the use of an automobile for that particular purpose out of the question.

These conditions, together with the constant bumping which a car receives in traffic and in parking, are not only apt to reduce materially the number of people who use or may use automobiles, but may result in still greater harm by putting into the minds of people the idea that not only commercial but pleasure uses of automotive vehicles are being made impossible by their inability to use them as, if, and where desired. Why should a man buy a car if he cannot use it with reasonable convenience and economy in going about his business? Unless a practical answer to this question can be found by making the use of an automobile as easy as it was, say, ten years ago, there will be a gradual tendency toward restricting the purchase of automobiles, thus creating an intangible—but all the more effective because of its intangibility —limit of saturation.

From this point of view it is remarkable that the enormous construction of new roads through the country has not brought about the expected relief, and that the congestion becomes worse and worse as the years go by. The explanation is, of course, very simple. Every new road has brought with it an increased number of users of motor cars, with the result that it would probably be fair to say that new traffic facilities, instead of bringing relief, only increase the previously existing congestion.

This condition is not limited to the United States only, and, for example, just at present the question of parking is a very burning one in Paris, where quite recently new rules have been promulgated by the local police department prohibiting all parking on busy streets within 50 meters of main thoroughfares, and limiting drastically the parking privileges everywhere else. It would appear, therefore, that not only this country but Europe as well is reaching a point of saturation in its traffic facilities, if not indeed an exhaustion of purchasing power for motor vehicles.

C. F. Scott Receives Edison Medal

C. F. SCOTT

THE Edison Medal, founded by associates and friends of Thomas A. Edison and awarded annually by the American Institute of Electrical Engineers for "meritorious achievement in electrical science, electrical engineering, or the electrical arts," was presented during the Winter Convention of the Institute, on Wednesday, January 29, 1930, to Charles Felton Scott, Chairman of the Department of Electrical Engineering at Yale University, and a member of the A.S.M.E.

From 1888 until 1911, when he went to Yale, Professor Scott was connected with the Westinghouse Electric and Manufacturing Company, where he was appointed chief electrician in 1897 and consulting engineer in 1904. He pioneered in the high-voltage transmission of electrical power and in the development of the induction motor and the transformer. The T-transformer connection, devised by him in 1894 for the transformation from two-phase to three-phase or vice versa, is known as the "Scott" connection. He also studied insulator problems, predicting the corona loss between high-tension wires, and made contributions to the early knowledge of inductive interference.

Aside from his notable achievements in the field of electrical engineering, Professor Scott is widely known for his interest in education. Starting during the Westinghouse days when he founded the Westinghouse Club for the training of young engineers, and continuing throughout his entire life, Professor Scott has given much thought and energy to educational problems, and these have resulted in constructive contributions of far-reaching importance. Particularly notable has been the instigating and guiding spirit with which he effected an organized investigation of engineering education under the auspices of the Society for the Promotion of Engineering Education and a grant of funds from the Carnegie Corporation. This work, the splendid results of which are so well known to engineers, was proposed by him as president of the S.P.E.E. in 1921–1923.

Another service of incalculable importance to engineers which Professor Scott has rendered was his vigorous advocacy of a national engineering headquarters, which led to the gift, by Mr. Andrew Carnegie, of the Engineering Societies Building in New York and the Engineers' Club. Professor Scott acted as chairman of the building committee.

Professor Scott is an honorary member of the American Institute of Electrical Engineers and was its president during the year 1902–1903. He had previously served as manager (1895–1898) and vice-president (1899–1901). He has served on many Institute committees, and is at present a member of the Lamme Medal and Student Branches Committees, and representative on the Commission of Washington Award and the American Engineering Council. He is also a member of the National Electric Light Association, Illuminating Engineering Society, American Philosophical Society, and the Engineers' Society of Western Pennsylvania (past-president). He has received the following honorary degrees: M.A., Yale University; Sc.D., University of Pittsburgh; and Eng.D., Stevens Institute of Technology.

Impressions of the World Engineering Congress

By JOSEPH W. ROE,[1] NEW YORK N. Y.

NEWS of the trip to Tokyo and the meeting of the World Engineering Congress and the World Power Conference has been sent home, and brought back by returning delegates. A few impressions of the Congress may, however, be of interest, especially when contrasted with those obtained from a brief trip to China, made immediately after the Congress excursions in southern Japan.

It is hard to say just when and where the Congress began—certainly long before Prince Chichibu opened the sessions in the Auditorium in Hibiya Park. For most of the Americans it began in the rain at Pennsylvania Terminal in New York—the last rain for many weeks.

The trip overland in the special train, with the brilliant dinner given by the Japanese Ambassador in Washington, and stops at Grand Canyon and Los Angeles, closed with a sun-lit afternoon drive from San Francisco down the peninsula to Palo Alto the day before sailing.

VISCOUNT SHIBUSAWA

THE WESTWARD VOYAGE

Owing to the large number who had come on the train or had joined the others at San Francisco, it was necessary to divide the party for the sea trip. There were therefore two official steamers, the *Korea Maru* and the *President Jackson*, which sailed the same day, were in sight of each other much of the time, and arrived at Honolulu and Yokohama together. On the *Korea* were most of the European delegates, who were going via the United States, and part of the American delegation and its chairman. The rest of the American group filled the *Jackson*. The trip over was broken by a two-days' stay at Honolulu, where the party came together again as a whole. Dr. Koettgen, of Berlin, said that when they were in California they thought they were nearing heaven, but in Honolulu they knew they had reached it. The Hawaiian music and dances under a great banyan tree, with the background of the ocean and Waikiki Beach in a flood of moonlight, formed an experience none will forget.

The sea was smooth until the last evening, when a typhoon hit both ships, and for a few hours gave the party a taste of an 80-mile gale. It passed during the night, and they sailed up Tokyo Bay at daybreak with a glorious view of Fuji hanging in the air, its snow cap tinged with the sunrise.

At the pier were the Japanese Committee, the foremost men of the nation, school children, banners, rickshas, motor cars, and a welcome which was a foretaste of the weeks to come. Owing to the unexpectedly large number of overseas delegates it was necessary to distribute them among three hotels in Tokyo and one in Yokohama, but by the opening of the Congress all were well cared for. A bulletin issued during the Congress gave the registration as of September 15. These figures show participation by more than 500 overseas delegates and guests from 23 countries, the United States being first with 242, China second with 60, Germany with 50, Great Britain with 45, and the rest with smaller representations. The Japanese participation was over 3000.

THE SESSIONS

The opening session, on October 29, was a brilliant scene with Prince Chichibu, brother of the Emperor and Heir Apparent, as the central figure. Behind him and on either side were the gray-haired Japanese ministers and industrial leaders, the Diplomatic Corps, and the chairmen of the various national delegations. The visitors realized then that the welcome and hospitality of the entire nation were theirs.

The professional sessions began on the next day, and ran each morning and most of the afternoons for six days. There were twelve sections of the Engineering Congress and four of the Power Conference. In all there were about 800 papers listed for the Engineering Congress and 160 for the Power Conference. Of these, about 200 World Engineering Congress papers were available in preprints, and a larger proportion for the World Power Conference. The largest group of World Engineering Congress papers, 322, were presented by Japan. The United States was next with 107, with Italy, Great Britain, and Germany, respectively, following. The total number of foreign papers was 414. Everywhere the sessions were crowded to the walls with Japanese engineers, executives, professors, and students. There can be no question of the great educational value of the Congress to Japan, and the opportunity it offered was utilized to the full. English and Japanese were the official languages. In the meeting of the Institute of Pacific Relations also, which was being held in Kyoto at the same time, English was used. It was clear in both conferences that this was the medium which reached the widest number. English is a required study in the public schools throughout the Empire, and it is said that within a generation 80 per cent of Japan's population will have some working knowledge of it.

Naturally the sessions which drew the largest number were those dealing with power and hydroelectric developments, as there is no place in the world at this time where these phases of engineering are more active. Japan has a heavy and dependable rainfall and steep, swift rivers everywhere. These are being utilized to an amazing extent. In the industrial sections about Nagoya and Osaka the power lines are so thick that the countryside reminds an American of a prosperous oil district. Hardly a village in central Japan is without electric light and power. This explains the keen interest in the subject.

Those who had attended other world congresses felt that this

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one measured up to any held elsewhere, and the Kogakkai, the great Japanese engineering society which carried the responsibility and labor of organizing and conducting the Congress, has made a signal contribution to engineering progress. The foreign delegates owe an especial debt to Baron Shiba and to Professor Kamo, both of them visitors to the United States and Europe, in the interest of the Congress. Their influence was evident at every turn.

Fewer Papers a Desideratum

One of the impressions gained was the desirability in future meetings of curtailing the number of papers. It was possible at Tokyo to print and present only a small proportion of the papers accepted. Some of these were of local rather than general engineering interest, or dealt with minor phases. With the crowded program some papers prepared by world authorities in which there was wide interest could be presented only in briefest abstract, if at all, and had little or no discussion. In future meetings it might be well to consider placing the papers in charge of a general international committee which would select definite subjects for consideration and have a relatively small number of papers presented by request by engineers, each chosen as a world authority in his field, these papers to be available in preprints to all delegates in ample time for preparation of well-considered discussion. This would not only center attention on major topics, but would bring down the formidable proportions of the transactions. The final transactions of the World Engineering Congress will run into 20 volumes, totaling over 10,000 pages. No one engineer can have direct interest in more than the smallest part of so much material. Its value as a picture of the engineering arts as of this time is real, but will lie chiefly in library reference use. This is offered as a suggestion rather than a criticism.

Construction Work in the Larger Cities

All the factories and engineering operations were wide open to the delegates, and the reconstruction of Tokyo and Yokohama was in evidence on every hand. The rebuilding of these cities after the earthquake and fires of 1923 has been one of the great engineering and economic tasks of modern times. Two-thirds of Tokyo, a city of more than 2,000,000 inhabitants, and nearly all of Yokohama, with close to 400,000, have been laid out in accordance with the best standards of city planning, with wide, straight streets and broad avenues to act as fire breaks. In the business sections, eight-story steel-frame and concrete buildings are general. These are built in accordance with a new code, with special heed to earthquake-proof and fire-proof construction. This code is said to be the severest in the world, entailing about 50 per cent increase in cost. Rickshas are fast disappearing before the "1-yen" taxi, which is not only faster but cheaper for all but short distances. Tokyo has its trolley cars and elevated, and, to give the New Yorkers a homelike feeling, its streets are being torn up for the building of a subway.

Japanese Hospitality Unmatched

While the professional sessions were notable and successful, it is probably the entertainment and excursions which will stand out longest in the memories of the foreign delegates. There is a quality in Japanese hospitality unmatched elsewhere, and Japanese life and scenery have a charm all their own.

The entertainment during the Congress included the Imperial garden party and afternoon tea, receptions, dances, Japanese plays, luncheons and dinners in the leading clubs, etc. Through all of them there was a coordinated variety. For example, at Baron Mitsui's we saw a Nō play, at the Imperial Theater the older Japanese drama, and at the Kabuki Theater, modern drama. At Baron Iwasaki's we saw Japanese gardening at its best, chrysanthemums of unbelievable delicacy in form and color, miniature landscapes, tiny pines, palms, and maples, some of them 300 years old, which should not be called *dwarf* trees, because that word with us connotes deformity and grotesqueness. The idea is rather that of miniature perfection and scaled proportion. Elsewhere we had Japanese music and Geisha dancing, juggling, acrobats, and, for the ladies, flower arrangement and the details of Japanese homes and domestic life.

All of this was packed into every chink of time available. A breathing spell was thoughtfully provided over the week-end during the session by trips to Nikko and Hakone, the former with its temples and matchless cryptomerias, one of the noblest trees that grows, and the latter with its mountain scenery and views of Fuji.

During the trips which followed the Congress we saw other characteristic things: jiu jitsu, fencing, wrestling, marvelous puppets, the tame deer at Nara, rickshas, etc. Everywhere the Japanese ladies joined with their husbands in this hospitality, and gave it added charm.

Excursions Following the Conference

Through the courtesy of the Government railways, passes were provided for every official delegate and his wife, covering the entire Empire, Korea, and Formosa; and for two weeks after the formal close of the Congress on November 7, the hospitality given at Tokyo was extended elsewhere. At Nagoya, Kyoto, Nara, Osaka, Kobe, and Nagasaki there were formal entertainments to large groups. Smaller groups were shown various engineering works, covering mines, hydroelectric plants, shipyards, factories and anything of special interest to individuals. These post-congress trips included the scenic beauties of Lake Biwa, Miyajima, Beppu, Unzen, Atami, and Matsushima. Those who visited China were also given by the Chinese Government and engineers the courtesies of the Chinese railroads, and dinners in Peiping, Tientsin, and Shanghai.

On the trips during and after the sessions there was opportunity to see the country and its life as no tourist could do in a long time, if at all. We saw cities and country villages, large factories and handicraft industry, school children and workmen. Some experiences were revealing and humbling, as, for instance, to see a busy city of a million inhabitants, Nagoya, the name of which some had not even heard. Few of us realized that Osaka is larger than Tokyo, and that both are well over 2,000,000. At every hand we met and saw the influence of returned students who had been trained in American colleges and engineering schools. American automobiles are everywhere, and will increase with the rapidly spreading highway system. The hydroelectric development has been mentioned. The Mitsubishi shipyard at Nagasaki employs 10,000 men and turns out 100,000 tons of shipping a year. The 30,000-ton *Asama Maru*, which recently broke all records on the Pacific, is an example of what Japanese shipyards can do. Two more liners, the *Chichibu Maru* and *Tatsuta Maru*, just going into commission are as large and splendid as the *Asama*.

Japan's Economic Problem

Japan is not only being industrialized on modern lines, but her industries are under her own control. The railways are almost wholly owned and operated by the Government. Large stock companies, Japanese-owned, dominate the fields of mining, manufacturing, shipping, and finance. Agriculture is almost everywhere on a small-farm basis—unbelievably small, but most intensive. The government is fostering by every possible means the silk, rice, and tea industries, as well as reforestation and the fisheries.

Japan's economic problem is difficult. She has about the same area as Great Britain, but only 20 per cent of her area is available for agriculture as against about 80 per cent for Great Britain; and her population is 63,000,000 as against 40,000,000 for the latter, and is increasing about 750,000 per year. This growing population cannot go elsewhere, and the answer seems to be to transform the nation from an agricultural one, which it has been heretofore, into an industrial one, and to manufacture for export. This is, of course, just what England has done during the past 150 years. For this Japan's presence in the Orient with its vast markets is a great advantage, and she is rapidly building up a merchant marine which is competing actively with the older maritime nations everywhere. The N.Y.K. and O.S.K. lines, both have round-the-world services, and Japanese ships crowd all the Asiatic ports. The Japanese, like the English, are an island people and natural seafarers, and take to modern sea traffic like ducks to water. Those who went over on the *Korea Maru* had a good example of this.

Japan's work in Korea and Formosa is perhaps the severest test of her whole development for the past 75 years. What she considers wise and constructive there, and the character of the administration she provides, is a fair index of the quality of her own governmental standards. The record of her administration there will, I think, bear comparison with that of France in North Africa, England in India, and the United States in the Philippines, and would place here beside these nations as one of the great modern powers.

CHINA

Even the briefest visit to China, especially one after such a trip as ours in Japan, is a demonstration of the importance and function of government in modern society. Japan, no larger than some of the single provinces in China, is full of energy, is growing rapidly in wealth and population, with a steadily rising standard of living, and has taken her place as an equal at the council board of nations. China is a bewildered and staggering giant, almost helpless, with transportation facilities meager and unsafe, internal commerce almost stopped, and the common people struggling for mere existence. Those who know both peoples rate the Chinese as highly as the Japanese. The difference between the situations of the two nations seems largely due to the difference in the quality of their governments. One is united, alert, and highly intelligent, with the whole people behind it. The other is disrupted, beset outside and in, and ineffective in almost every function. If China had had the quality of national leadership, unbrokenly, for the past 75 years which Japan has enjoyed during that time, and had given it the same united support, there is no telling what her status today might be. Japan has shown China the way. Will she take it?

A trip to China today is not only the best background imaginable for appreciating the great achievement of Japan in transforming a medieval, handicraft civilization into a modern, effective, forward-looking one. It emphasizes the lesson of the Tokyo Congress in showing how great a part engineering has taken in that achievement.

Auguste C. E. Rateau
1863–1930

PIONEER in the development of the steam turbine, former professor of electrical engineering at the École Supérieure des Mines de Paris, designer of centrifugal compression machinery and the aeronautical-engine supercharger, founder and president of the great industrial establishment bearing his name, the Société Rateau, author of engineering papers, medallist, recipient of honorary degrees from universities in the United States of America, Great Britain, and Europe, second engineer to receive the distinction of election to the Institut (Académie des Sciences), Commander in the Légion d'Honneur, and honorary member of the A.S.M.E., Auguste Camille Edmond Rateau died in Paris, January 13, 1930, at the age of 66. An appropriate memoir and an appreciation of his work will appear in a later issue of MECHANICAL ENGINEERING.

Hugh Longbourne Callendar
1863–1930

HUGH LONGBOURNE CALLENDAR, professor of physics at the Imperial College of Science, London, England, and best known to readers of MECHANICAL ENGINEERING for his experiments in steam and the tables of the properties of steam that bear his name, died suddenly on January 22, 1930, at the age of 67.

HUGH LONGBOURNE CALLENDAR

Professor Callendar was born in Hatherop, Gloucestershire, in 1863, the son of Hugh Callendar, of Magdalene College, Cambridge. He was educated at Marlborough and at Trinity College, Cambridge University. In 1893 he came to America, when he became professor of physics at McGill University, Montreal, Canada. Here he remained until 1898, when he returned to England as professor of physics at University College, London. In 1902 he became professor of physics at the Imperial College of Science, a position which he held at the time of his death.

Professor Callendar was highly esteemed in this country as well as in England where his researches had made him famous. In 1894 he was elected a fellow of the Royal Society, and in 1896 a fellow of the Royal Society of Canada. He was awarded the Rumford Medal of the Royal Society in 1906, and the first Duddell Memorial Medal of the Physical Society in 1924. In 1920 he was made a Commander of the Order of the British Empire.

Theoretical and experimental work in heat and thermodynamics constituted Professor Callendar's principal contributions to science and engineering. He was the chief authority on the subject of the thermal properties of steam in Great Britain. His researches on steam at high pressures and temperatures, still in progress at the time of his death under the auspices of the British Electrical and Allied Industries Research Association, resulted in the formulation of the Callendar steam equation. His publication in this field include "Callendar Steam Tables" (1915); "Properties of Steam and Thermodynamic Theory of Turbines" (1920); "Enlarged Callendar Steam Tables" (1924); and an enlarged Mollier or H-ϕ diagram for saturated and superheated steam (1926). His steam tables have been adopted by the British Electrical and Allied Manufacturers' Association as standard. In his report of 1925 he presented a continuous-flow method of measuring the total heat of steam at high pressures.

Professor Callendar played an important part in the Inter-

national Steam-Table Conference reported in the October, 1929, and February, 1930, issues of MECHANICAL ENGINEERING, and in the initial steps taken at that conference toward an agreement among the principal investigators in the field of steam research.

Professor Callendar is also known for his papers on the electrical resistance thermometer with the Callendar-Griffiths bridge and recording devices, published in 1886–1887; for a compensated air thermometer, 1891; for a method of measuring the specific heats of liquids by means of a continuous-flow calorimeter, described in 1902; and a radio balance, 1910. In 1926 he reported to the Air Ministry the work which he and his associates had carried out on dopes and detonation, and in 1927 their work on the effect of anti-knock compounds.

Sebastian Z. de Ferranti
1864–1930

SEBASTIAN ZIANI DE FERRANTI, pioneer in the generation and distribution of electrical power at high voltages and head of Ferranti, Ltd., Hollinwood, near Manchester, England, designer of the famous Deptford Station and honorary member of the American Institute of Electrical Engineers, died in Zurich, Switzerland, on January 13, 1930.

S. Z. DE FERRANTI

Dr. Ferranti was born in Liverpool on April 9, 1864. He was educated at Hampstead School and St. Augustine's College, Ramsgate, where he finished the construction of a small dynamo. At the age of seventeen he was assisting Sir William Siemens in the development of an electric furnace for making steel.

Ferranti was a young man when electric lighting first made its appearance in England. In 1882 he invented and patented the alternating-current generator bearing his name. In 1886 he was called upon to reorganize the small electric-light plant at the Grosvenor Gallery, Bond St., London. During his experience at Grosvenor Gallery he conceived the idea of a central station, located outside of congested areas and supplying them current from a distance, an idea that was opposed to the tendency of the times, which was the small electric-light station supplying customers in its immediate vicinity. Convinced of the practicability of his idea, Ferranti set about to design and construct a station at Deptford, in which 10,000-hp. engines were to drive generators supplying 10,000-volt current. With no prior art to guide him, Ferranti was faced with innumerable technical difficulties, but these would have been overcome if his market for power had not been taken from him by legislative restrictions and curtailed by competition from local stations. In consequence, the engines were of 1250 hp. instead of 10,000 (although the latter were actually designed and built). Transmission was, however, at 10,000 volts, and Ferranti was confronted with problems of designing cables and transformers to make this high voltage practicable. His successes in the solution of these and other problems demonstrated his greatness as an inventor and as an electrical engineer.

Mechanical engineers have been greatly interested in Ferranti's engine and turbine designs, and in the great works at Hollinwood which bears his name, Ferranti, Ltd. His early advocacy of such modern practices as the use of steam turbines, high steam temperatures, and resuperheating during expansion, marked him as an engineer of clear vision and unusual genius. In addition to his epochal contributions in the field of electrical generation and distribution, Ferranti was a productive inventor. Between 1882 and 1927 he took out no less than 176 patents which cover a field so wide as to be almost unbelievable. His death marks the passing of one of the greatest pioneers of the electrical age.

Two Engineering Conventions

IN JANUARY were held the annual conventions of the American Society of Civil Engineers and the American Institute of Electrical Engineers, in New York City.

During the convention of the A.I.E.E., Prof. C. F. Scott was awarded the Edison Medal, as noted elsewhere, and R. E. Hellmund, chief electrical engineer of the Westinghouse Electric and Manufacturing Company, the Lamme gold medal for "meritorious achievements in developing machinery and apparatus."

Among the papers of technical interest and popular appeal was one by a General Electric engineer, K. B. McEachron, describing a new material, called Thyrite, for lightning arresters. Thyrite is a molded compound including silicon carbide, and has an electrical property by virtue of which its resistance decreases with an increase in voltage. Samples of the substance have a resistance of 50,000 ohms at 100 volts, and of less than half an ohm at 10,000 volts.

At an evening session held jointly with the Illuminating Engineering Society, ultra-violet radiation was discussed. Dr. M. Luckiesh, of the National Lamp Works of the General Electric Company, described a new electric lamp that closely simulates sunlight, both in color and in health-giving powers. When the lamp is turned on, a tungsten filament glows and its heat vaporizes mercury in a little pool at the bottom of the lamp. A mercury-vapor arc is then formed between two tungsten electrodes. About 68 per cent of the light comes from the glowing electrodes, 25 per cent from the arc, and the remaining 7 per cent from the filament. A transformer is used to step the voltage down to the 11 volts on which the lamp operates. While the lamp is 50 times as effective in tanning the skin as is midday summer sunlight of equal intensity, the bulb, which is of glass, cuts out some of the more harmful ultra-violet rays, so that no more caution is needed in exposing the eye to the light than one would use with midsummer sunlight.

At this same session, Dr. H. C. Rentschler, of the Westinghouse Lamp Company, described an instrument making use of a uranium-electrode photoelectric cell, which measures the intensity of the health-giving ultra-violet rays.

The American Society of Civil Engineers at its convention honored Ralph Modjeski, bridge builder, with the award of the John Fritz Medal. On the occasion of the presentation of the Medal, Dean D. S. Kimball, Past-President, A.S.M.E., gave the address, taking as his subject "The Engineer in Human Progress."

Of especial interest to mechanical engineers was the report of the power division presented by Geo. A. Orrok, who noted, among other things, the development of the use of propeller-type turbines and the wide application of welding.

The Kill van Kull arch bridge which the Port of New York Authority is building was discussed at two sessions occupying a full day. The excursions included visits to inspect the construction work on this bridge and to see the spinning of the cables of new Hudson River suspension bridge.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Books Received in the Library

AGENDA DUNOD, 1930. Automobile, by G. Lienhard; Chemins de Fer, by P. Place; Construction Mécanique, by J. Izart; Électricité, by L. D. Fourcault; Metallurgie, by A. Roux; Physique Industrielle, by J. Izart. Paris, Dunod, 1930. Bound, 4 × 6 in., 6 v., illus., tables, 20.50 fr. each.

These pocketbooks, which are revised each year, are prepared with the ordinary requirements of designers, builders, and operators in mind. Each volume contains the mathematical formulas, physical and chemical constants, and general data frequently needed. The size is an actual pocket size. The amount of information supplied is remarkable, in view of the surprisingly low price of the volumes.

ATLAS METALLOGRAPHICUS, Parts 6 & 7, Plates 41–56. By Hanemann and Schrader. Gebrüder Borntraeger, Berlin, 1929. Paper portfolios, plates, 8 × 11 in., 7 r.m. each.

These two new sections of this atlas contain 128 photomicrographs showing the effect of various heat treatments on the structure of iron and steel. Full information concerning the composition, heat treatment, and etching is given in each case. The specimens are beautifully reproduced.

MITTEILUNGEN DER DEUTSCHEN MATERIALPRÜFUNGSANSTALTEN, Sonderheft 9. Kaiser Wilhelm-Institut für Metallforschung und dem Staatlichen Materialprüfungsamt zu Berlin-Dahlem. Julius Springer, Berlin, 1929. Paper, 8 × 12 in., 149 pp., illus., diagrams, tables, 22.50 r.m.

The twenty reports collected in this volume discuss various structural and mechanical properties of industrial metals. The influence of lead on the structure of brass; age hardening of silver-aluminum alloys, the influence of various metals on the properties of cast iron, the aging of duralumin, and a variety of problems connected with the subject of metal crystals are investigated.

MITTEILUNGEN DES HYDRAULISCHEN INSTITUTS DER TECHNISCHEN HOCHSCHULE MÜNCHEN. No. 3. Edited by D. Thoma. R. Oldenbourg, Munich and Berlin, 1929. Paper, 8 × 11 in., 163 pp., illus., diagrams, tables, 12 r.m.

The research reports in this volume include, among others, investigations of sources of error in overflow measurements, the design of the Thoma return-current brake, the loss in right-angle pipe bends of constant section, the loss of energy in pipe bends, friction losses in transversely lapped pipe, the lubricating value of oils, and the influence of the viscosity of water on the efficiency of a small Francis turbine.

PHOTO-PROCESSES IN GASEOUS AND LIQUID SYSTEMS. By R. O. Griffith and A. McKeown. Longmans, Green & Co., New York, 1929. (Textbooks of Physical Chemistry.) Cloth, 6 × 9 in., 691 pp., diagrams, tables, $8.50.

Intended as a textbook for senior students and research workers. The first half is devoted to those topics in modern physical theory, such as atomic and molecular structure and spectra, photoluminescence, and chemiluminescence, which are the fundamentals of photochemistry. The remainder deals with photochemical changes, their energetics, kinetics, and reaction mechanisms. The book is concerned especially with the intensive research work of the past fifteen years.

QUANTUM MECHANICS. By Edward U. Condon and Philip M. Morse. McGraw-Hill Book Co., New York, 1929. (International series in physics.) Cloth, 6 × 9 in., 250 pp., $3.

This book aims to give an account of some of the leading developments in our knowledge of atomic structure and the interpretation of spectroscopic and electronic phenomena which have been made since 1924. Building inductively from the phenomena to be explained, the authors set forth, as simply as possible, the prevalent theory of the quantum mechanics, and give an outline of the results obtained by it, with an account of various methods used to arrive at them.

RAYON INDUSTRY. By Mois H. Avram. Second edition. D. Van Nostrand Co., New York, 1929. Cloth, 6 × 9 in., 893 pp., illus., tables, $12.

This treatise discusses all phases of the industry, economic, engineering, and chemical, and is intended to present the salient facts wanted by engineers, manufacturers, and investors. The topics treated include the raw material, the chemical and textile processes, plant design and equipment, the production of finished textiles, business and industrial organization, and the financial and economic background. The new edition is greatly enlarged, and much improved in arrangement. Useful lists of patents and an extensive bibliography are included.

RÉGLAGE ET ESSAIS DES MOTEURS A EXPLOSION. By R. Lamy. Dunod, Paris, 1929. Paper, 7 × 10 in., 308 pp., illus., diagrams, 69.70 fr.

This work, by the chief of the aviation service of the Zenith Carbureter Co., is a theoretical and practical treatise on the action of explosion engines, and on methods of testing and regulation. The phases through which the fuel passes are explained, with the factors that influence the execution of them. Carburation, distribution, and ignition are discussed in detail.

Laboratory test methods are outlined for both automobile and aviation engines.

REORGANIZATION OF CREWE LOCOMOTIVE WORKS. London, Midland & Scottish Railway. *Railway Engineer*, London, 1929. Cloth, 9 × 12 in., 118 pp., illus., plates, forms, 15 s.

A radical reorganization of the famous Crewe Locomotive Works, carried out during the last three years, has effected remarkable economies in the cost of building and repairing locomotives, and in the time required. Complete repair jobs formerly requiring as many as sixty days are now done in a maximum of twelve.

The reorganization of machinery, transportation, and labor distribution in the plant and the production methods adopted are described in detail in this account, which appeared first in the *Railway Engineer*. Numerous drawings and photographs are included.

DAS SCHALTWERK...DER SIEMENS-SCHUCKERTWERKE. By Hans Dominik. S. Hirzel, Berlin, 1929. (Musterbetriebe Deutscher Wirtschaft, bd. 11; Der Schaltgerätebau.) Boards, 6 × 9 in., 86 pp., illus., price not indicated.

A detailed description of the new plant for manufacturing switchgear of the Siemens-Schuckert Works in Berlin. The construction and arrangement of the buildings and the methods for the planning and control of production are explained, with the aid of numerous illustrations. The book is one of a series designed to show, by describing typical modern examples, the way in which Germany is adopting modern ideas of scientific management.

SCIENTIFIC MANAGEMENT IN AMERICAN INDUSTRY. By the Taylor Society; H. S. Person, editor. Harper & Brothers, New York, 1929. Cloth, 6 × 9 in., 479 pp., forms, charts, data sheets, $6.

A comprehensive treatise planned and prepared by the Society. Management research, management standards, the control of operations and the maintenance of standards, and the human aspects of scientific management are discussed by twenty-six authors. The result is a valuable statement of present experience and practice, covering all phases of manufacturing and marketing.

SOURCE BOOK IN MATHEMATICS. By David Eugene Smith. McGraw-Hill Book Co., New York, 1929. (Source Books in the History of the Sciences.) Cloth, 6 × 9 in., 701 pp., illus. portrait, $5.

Teachers and students of mathematics will find interesting this collection of the most significant passages from the works of some of the makers of that science. The selection covers a wide range and includes something to interest workers in any branch of mathematics. Material from foreign languages has been carefully translated, and useful historical and biographical notes have been added.

STEEL TREATING PRACTICE. By Ralph H. Sherry. McGraw-Hill Book Co., New York, 1929. Cloth, 6 × 9 in., 399 pp., illus., tables, $4.

This book aims to outline the requirements of practice rather than to discuss the theory of steel treating. The basic principles are presented briefly, with a description of standard shop practice, and commercially important variants, in annealing, hardening, and carburizing steels. Furnaces and fuels, pyrometers, control and inspection, andt he arrangement and equipment of treating plants are discussed in a practical way. The industrial aspects of the subject are emphasized throughout the book.

TRANSPORT AVIATION. By Archibald Black and others. Second edition. Simmons-Boardman Publishing Co., New York, 1929. Cloth, 6 × 9 in., 348 pp., illus., diagrams, tables, $5.

This volume will appeal to business men and investors interested in studying the possibilities of aerial transport. The present status of civil aviation, the cost of airplane operation, the probable development of the industry, the legal problems and other matters of that nature are discussed by fifteen specialists. The new edition has been entirely rewritten and greatly enlarged.

UNTERSUCHUNGEN ÜBER DIE STRÖMUNGEN DES WASSERS IN KONVERGENTEN UND DIVERGENTEN KANÄLEN. By Johann Nikuradse. (Forschungsarbeiten. . . . heft 289.) V.D.I. Verlag, Berlin, 1929. Paper, 7 × 11 in., 49 pp., diagrams, tables, 6 r.m.

Gives the results of a careful experimental study of turbulent flow of water in divergent and convergent channels, and of distribution of velocities and pressures in these currents. The results obtained are compared with those obtained by other investigators upon air currents.

DIE VEREINFACHTE BERECHNUNG BIEGSAMER PLATTEN. By H. Marcus. Second edition. Julius Springer, Berlin, 1929. Paper 7 × 10 in., 126 pp., diagrams, 9 r.m.

This simplified method of calculationg elastic slabs has the approval of the Deutscher Ausschuss für Eisenbeton, which has adopted it for its official determinations. The author here sets forth the principles of his method of approximation, gives his formulas, and illustrates their use in calculating floor slabs.

VORLESUNGEN ÜBER MASCHINENELEMENTE, No. 4; Reib- und Rädertriebe. By M. ten Bosch. Julius Springer, Berlin, 1929. Paper, 8 × 11 in., 97 pp., illus., diagrams, 7.80 r.m.

In response to a need for a concise, modern text on machine elements, Professor ten Bosch has published the course given by him at the Zurich Institute of Technology. The present section on power-transmitting devices discusses the theory and design of friction wheels, toothed gearing, belt and chain drives, and mechanical brakes. The treatment is a practical one.

WÄRMEWIRTSCHAFT IM EISENBAHNWESEN. By Fr. Landsberg. Theodor Steinkopff, Dresden and Leipzig, 1929. (Wärmelehr und Wärmewirtschaft. . . v. 7.) Paper, 6 × 9 in., 207 pp. illus., diagrams, tables, 13 r.m.

An application of the general principles of fuel economy to the specific problems of railroad operation. Covers all the various uses of fuel in train operation; in shops, and in stations. The organization of the fuel department is considered, as well as technical methods of economy.

Research Committee on Elevator Safeties Doing Important Work

(Continued from page 200)

M. B. MCLAUTHLIN, President, Geo. T. McLauthlin Co., Boston, Mass., representing the Elevator Manufacturers Association of U. S.

W. S. PAINE, Manager, Engineering Inspection Department, Aetna Life Insurance Co., Hartford, Conn., representing the National Bureau of Casualty and Surety Underwriters

S. F. VOORHEES, Architect, Voorhees, Gmelin & Walker, New York, N. Y., representing the American Institute of Architects.

The technical advisers to the committee are:

C. R. CALLAWAY, Vice-President, Gurney Elevator Company, New York, N. Y.

N. O. LINDSTROM, Works Manager, A. B. See Elevator Co., Jersey City, N. J.

C. L. MAAS, Atlantic Elevator Company, New York, N. Y.

G. PERSSON, A. B. See Elevator Company, New York, N. Y.

G. H. REPPERT, Engineer, Otis Elevator Co., New York, N. Y.

H. H. WATTERS, Otis Elevator Co., New York, N. Y.

The research work is being performed at the Bureau of Standards by John A. Dickinson, who was appointed research associate, and also serves as secretary of the Sub-Committee.

Synopses of A.S.M.E. Transactions Papers

THE papers abstracted on this and following page appear in the current issues of the Aeronautic, Iron and Steel, and Materials Handling sections of A.S.M.E. Transactions. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced when completed, in later issues of "Mechanical Engineering."

AERONAUTICAL ENGINEERING PAPERS

RADIAL VERSUS IN-LINE ENGINES. By Glenn D. Angle. [Paper No. AER-51-32]

In this paper the author, after recounting the history of the two types of engines under consideration, sets forth at some length reasons why the in-line type has been revived. Following this he compares the two types as regards such features of primary importance to the airplane manufacturer as weight per horsepower, cost, smoothness of operation, installation, visibility, cooling, and head resistance. He concludes that the radial engine is inherently superior on the basis of weight per horsepower, smoothness of operation, installation, service, and cooling. It also promises to excel in the matter of low manufacturing costs. The upright in-line engine, by virtue of its smaller frontal dimensions, is possibly better for visibility in some installations, although this advantage becomes of little consequence in certain types of airplanes. The inverted in-line type obviously excels in visibility, in almost any installation. The comparative resistance or drag of the radial and the in-line engine, however, is still a matter of opinion.

DEVELOPMENT OF THE COMMERCIAL AIRPLANE. By G. M. Bellanca. [Paper No. AER-51-33a]

This paper outlines some of the factors that have contributed to present-day success in aviation, and comprises a discussion of single- and multi-engine airplanes.

RELATION BETWEEN COMMERCIAL AIRPLANE DESIGN AND COMMERCIAL USES OF AIRPLANES. By T. P. Wright. [Paper No. AER-51-33b]

This paper presents some of the problems of the airplane designers, together with an indication of a trend in airplane design which it is felt possibly may take place. The following topics are discussed: fundamental requirements, design elements, commercial uses of airplanes, and airplane designs.

Under the last item, an attempt is made to analyze the points discussed in the preceding ones, with a view to suggesting certain design arrangements which seem most logically to fulfil the requirements which the airplane so designed must meet.

MANAGEMENT OF AN AIRPORT. By Major John Berry. [Paper No. AER-51-34]

The author gives details of the inception and development of this the first municipally owned and operated airport, and enumerates the facilities which it possesses. He further sets forth various precautions which should be observed in the operation of an airport which are based on his experience as manager of the airport since its operating.

SCIENTIFIC STUDIES OF NATURAL FLIGHT. By Maurice Boel. [Paper No. AER-51-35]

In this paper the author gives the results of studies and experiments in bird flight with a view to bringing out features that can be used to advantage in future construction of airplanes. Birds can remain stationary in the air, they can rise and descend almost vertically, and can alight on a particular spot slowly. These are maneuvers not yet possible with airplanes.

The author has also developed a new theory of flapping flight. He renounces the analogy between wings and oars, and shows that flapping flight consists of a succession of short descents in gliding flight. The bird by flapping its wings is lifted a certain amount, and when released moves forward by gliding.

Various classes of flight by birds are discussed under four general headings. They are gliding flight, soaring flight, propulsion flight, and flapping flight. The mechanics, speed, stability, and useful power of the various classes are worked out by typical examples to show how the various types of birds are adapted to particular types of flying. The exterior anatomy of birds, problems of flight, and resistance of air are discussed, and examples are given to show the influence of the lines of the bird on its aerodynamic characteristics.

THE METALCLAD AIRSHIP. By Carl B. Fritsche. [Paper No. AER-51-36]

The author sets forth the advantages to be obtained from the employment of all-metal construction in dirigibles, and discusses at length costs and other economic questions involved. Extended particulars are then given regarding the design, all-metal construction, erection, and assembly of the U. S. Navy Dirigible ZMC-2, together with data on dimensions, weight arrangement, shape and stress analysis, and performance, as well as conclusions on the test flights.

IRON AND STEEL PAPERS

ORE-HANDLING BRIDGES. By Alexander C. Brown. [Paper No. IS-51-4]

In this profusely illustrated paper the author, after briefly referring to the cable tramway first used for handling ore, takes up the development of the bridge type of tramway. The invention of the automatic grab bucket and the adoption of electric power, he points out, made possible the modern methods used in unloading and rehandling ore. He then discusses various methods which have been proposed to secure stability and safety in ore bridges in order to withstand wind storms of high velocity. Types of wind bracing are then dealt with, as well as skewing bridges for avoiding twisting stresses when one end of bridge travels faster than the other. The four travel mechanisms which have been largely used are described, following which tracks and track wheels are considered. The paper concludes with a brief discussion of improvements which have taken place in trolley design and distinguished from design of the bridge structure.

OIL-ELECTRIC LOCOMOTIVES IN STEEL-MILL TRANSPORTATION. By W. L. Garrison. [Paper No. IS-51-5]

Three classes of oil-electric locomotives developed for yard-switching service are discussed in this paper. Types of transmission systems described include the mechanical, hydraulic, pneumatic, and electrical. Advantages of oil-electric locomotives are outlined. They include operating economies, low maintenance, less truck repairs, and freedom from smoke and noise.

TEMPERATURE DISTRIBUTION IN COMBUSTION FURNACES. By M. H. Mawhinney. [Paper No. IS-51-6]

Metallurgical processes continue to become increasingly complicated and exacting, and their success very frequently depends upon the manner in which the metal is heated. One important requirement in the rational design of heating furnaces is uniformity of temperature distribution. The amount of published data on this subject is very small, and the purpose of the present paper is to add to it results of temperature measurements made in a test furnace to determine the temperature distribution in the heating chamber for different temperatures and different methods of firing.

AUTOMATIC ARC WELDING OF THIN SHEETS. By W. L. Warner. [Paper No. IS-51-7]

After briefly outlining the fusion-welding process, the author discusses in detail the various steps in the welding operation, noting the precautions to be taken in order to produce successful welds. He concludes by describing numerous applications of automatic arc welding in the joining of sheets and parts less than 1/4 in. in thickness.

SOME NOTES ON PRODUCER GAS AND OTHER FUELS. By Victor Windett. [Paper No. IS-51-8]

In this paper the author discusses operating conditions and costs for making gas. The relative values of fuels are given through various examples and calculations. These comparisons are based on producers complying with the more exacting requirements of present-day practice.

MATERIALS HANDLING PAPERS

SELECTIVE PACKAGE CONVEYORS. By W. O. Hildreth. [Paper No. MH-51-8]

Severe competition is forcing every manufacturing industry to secure the most efficient layout of machinery and the maximum output from every square foot of floor space. Economical handling of materials, orders, letters, and instructions within the plant are important to secure the highest efficiency.

Conveyors of many types are now available, and "selective" conveyors are an important variety. These are adapted for automatically delivering packages or materials to various predetermined points selected by the sender at the time the material is dispatched.

The selection of destination may be determined by the size or weight of the package itself or by the position of a movable finger or selective pin. If the material to be transported is carried in trays or tote boxes over a conveyor system the movable selective finger can be mounted upon the upper front edge of the tray. This selective finger, for light service, may itself be used to deflect the tray from a conveyor by means of a switch bar, or may operate an electric circuit maker to control the movement of a heavy deflector bar.

The latest method of selection employs a separate pilot car carrying the selective pin and followed upon the conveyor belt by a string of boxes, cartons, or bags which are all going to the same destination. The procession is followed by a caboose car carrying a selective pin which releases the deflector bar after the caboose has passed and allows the deflector to swing out of the path of passing pilot cars until another car approaches with its selective pin in the proper position to operate this particular deflector.

SYMPOSIUM ON THE SKID HANDLING OF INTERPLANT SHIPMENT. [Paper No. MH-51-9]

The first paper of this symposium, by C. B. Crockett, presents some of the economic aspects of the shipment of materials on skid platforms viewed purely from the standpoint of the shipper or receiver of the material. It deals with the equipment necessary and its uses, points out the small influence of freight transportation on total cost, and discusses the savings possible, giving illustrations of actual instances in various industries.

The second paper, by R. L. Lockwood, outlines the development of materials handling from 1890, first in the handling of bulk goods, then in handling materials of construction, and, more recently, in handling goods in process in factories. The author shows that handling materials is unique in that the savings it makes represent net gains which are shared by all elements in industry.

In the third paper J. V. Miller discusses the savings that can be effected in handling railroad stores by lift trucks and skid platforms, giving details of the procedure whereby one railroad has reduced its handling cost by about 65 per cent and the cars tied up in shipping stores by about one-third.

Following Mr. Miller, F. J. Shepard, Jr., outlines the development of the use of lift trucks for interior factory transportation, and briefly discusses their possibilities for interplant transportation and for use between cities through freight and motor-truck shipments. He shows how the methods of packing and transporting paper have been radically changed in the past two years through the use of skid platforms for shipment, and gives figures of savings effected in a number of instances.

In the fifth paper H. E. Stocker deals with the use of skids for water shipment. He states that in such work the handling can be reduced by keeping freight off the floor of the dock or the deck of the ship, and that the best method of accomplishing this is to receive freight from manufacturers already loaded on skids. In addition to the economy resulting from handling skids on the dock with light trucks, the author claims that the average sling load will be tripled, the ship's dispatch expedited, and the claims reduced, and that the total savings will be the equivalent of more than a 50 per cent cut in cargo-handling expenses.

In the closing paper Geo. B. Wright discusses skid platforms, stock skid boxes, and power-lift and hand-lift trucks in the handling of cargoes in Great Lakes navigation. He points out that the biggest problem to be faced is the practicability of interchange between carriers, and between carriers and industrial plants, and that the solution can only be arrived at through discussion carried on between the representatives of industries, steam railroads, electric lines, steamer lines, city transfer trucking companies, and storage warehouses.

HANDLING PAPERS AND SMALL ARTICLES BY PNEUMATIC TUBES. By James Whiting. [Paper No. MH-51-10]

Pneumatic tubes as applied to the handling of papers and small articles accomplish what the telephone does for the spoken word. They not only now move the mass of paper work attendant on our industrial activity, with its intensive distribution, keen competition, and large production, but are being applied continuously to the mechanical processes of production.

Applications of pneumatic tubes comprise $1\frac{1}{4}$-in.-diameter tubes handling radio messages, telegrams, telephone toll tickets, etc.; $2\frac{1}{4}$-in. tubes for general message and utility service; 3-in. tubes for handling tools, small machine parts, samples, etc.; 4-in. tubes handling hot ingot test pieces, gunpowder, paint samples, etc.; 5-in. tubes in testing laboratories and railroad freight yards; 3-in. × 6-in. oval tubes for bank service in handling pass books and deposits, and in publishing houses for carrying copy and proofs, etc., and 4-in. × 7-in. oval tubes handling complete folios of correspondence, insurance policies, etc.

The tasks to which pneumatic tubes are applied are innumerable and form a list which includes every industry, and as added applications are made in the general business world, other new applications become constantly apparent.

NOTE: Those who have not registered in the A.S.M.E. Aeronautic, Iron and Steel, and Materials Handling Divisions whose papers are abstracted on this and the previous page, and who desire copies of any of these papers, may obtain them by using the form given below.

TO THE SECRETARY, A.S.M.E., 29 West 39th Street, New York, N. Y. Date.....

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Current Mechanical Engineering Literature

Selected References From The Engineering Index Service

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THE ENGINEERING INDEX SERVICE furnishes to its subscribers a Weekly Card Index of references to the periodical literature of the world covering every phase of engineering activity, including Aeronautic, Chemical, Civil, Electrical, Management, Mechanical, Mining and Metallurgical, Naval and Marine, Railway, etc. Of the many items of particular interest to mechanical engineers a few are selected for presentation each month in this section of "Mechanical Engineering." In operating The Engineering Index Service, The American Society of Mechanical Engineers makes available the information contained in some 1700 technical publications received by the Engineering Societies Library (New York), thus bringing the great resources of that library to the entire engineering profession. At the end of the year all references issued by the Service are published in book form, this annual volume being known as The Engineering Index.

Photoprint copies (white printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents a page. When ordering photoprints identify the article by quoting from the index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication; (4) Page numbers. A remittance of 25 cents a page should accompany the order. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.

ABRASIVE MATERIALS

Testing. Determination of Breaking Strength of Granular Abrasives (Bestimmung der Bruch-eigenschaften gekoernter Schleifmittel), C. Krug. V.D.I. Zeit. (Berlin), vol. 73, no. 48, Nov. 30, 1929, pp. 1707–1709, 6 figs. Testing of corundum and silicon carbide; resistance against rapidly changing loads; curves for analyzing qualities from breaks, allowing for making of specifications for grinding wheels.

AERODYNAMICS

Air Resistance. Air Resistance at Very High Velocities (Der Luftwiderstand bei sehr grossen Geschwindigkeiten), J. Ackeret. Schweizerische Bauzeitung (Zuirch), vol. 94, no. 15, Oct. 12, 1929, pp. 179–183, 18 figs. Discussion of laws of resistance of air to bodies moving with very high velocities on basis of theoretical studies and experimental results obtained at Kaiser Wilhelm Institute of Aerodynamic Research; streamline photographs of projectiles; applications of these laws to ballistics, design of high-speed steam turbines and aeronautics.

AIRPLANE ENGINES

Cooling. An Improved Cooling System for Aircraft Engines, A. M. Jacobs. Air Corps News Letter, vol. 13, no. 16, Nov. 29, 1929, pp. 401–402. Description of tests made with Curtiss plant Model P-6 which was first pursuit plane built to incorporate engine high-temperature liquid cooling feature; improvements in airplane structure allowed by new engine cooling system; series of tests started with ethylene glycol; advantages in greater fuel economy and reduced radiator size.

High Temperature Cooling, B. Jones. U. S. Air Services, vol. 14, no. 12, Dec. 1929, pp. 34–37, 4 figs. Description of experiments made by Army Air Corps engineers in developing ethylene glycol for cooling airplane engines.

Diesel. Diesel Airplane Engines (Les moteurs diesel d'aviation), A. Frachet. Nature (Paris), no. 2815, Aug. 15, 1929, pp. 166–170, 7 figs. Problem of adaptation of Diesel engine to aviation as solved in Germany with Junkers engine and in England with Beardmore is discussed; of Diesel in safety from fire on board airplane; reliability in operation and simplicity of construction; possibilities realized in high-speed Diesel; Packard Diesel constructed in series; results of work of Junkers; test of Beardmore.

Manufacture. Layout of a Manufacturing Plant, F. L. Faurote. Iron Age, vol. 124, no. 26, Dec. 26, 1929, pp. 1730–1731. Description of layout of plant Wright Aeronautical Corp., for manufacture of airplane engines; foundations laid for system of mass production and unit assembly; engines mounted on special assembly frames equipped with wheels so that power unit may be moved along tracks as weight grows.

Reduction Gears. Gearing of Aircraft Propellers, T. P. Wright and R. E. Johnson. Soc. Automotive Engrs. Jl., vol. 25, no. 6, Dec. 1929, pp. 667–671 and (discussion) 671–672, 3 figs. Problem of propellers for use on geared-down engines; installation of reducing gearing between crankshaft of engine and propeller hub when increase of airplane performance characteristics more than offsets added complication of installation; advantages and disadvantages of reduction gearing; decision of when to use gears must result from compromise between gains and losses involved; amount of net gain depends largely upon particular engine and airplane combination and its designed performance.

Testing. Developing a New Type of Motor. U. S. Aviation Quarterly, vol. 1, 1929, p. 43. Discussion of various tests made at Aeronautical Engine Laboratory, Naval Aircraft factory, Philadelphia, which may effect profoundly design of internal combustion engines; tests on Prestone cooling liquid which would permit smaller radiator; possibilities of closed system.

The Effect of Fuel Consumption on Cylinder Temperatures and Performance of a Cowled Wright J-5 Engine, O. W. Schey. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 328, Nov. 1929, 18 pp., 9 figs. on supp. plates. Results of tests on Wright J-5 air-cooled engine; enriching mixture by increasing carburetor jet size results in reduction in cylinder-head and barrel temperatures; cylinders shielded by magnetos or points on cylinder that do not receive free flow of cooling air increase most rapidly in temperature as mixture is leaned; Wright J-5 engine can withstand severe temperatures for short periods of operation.

Valves. Noteworthy Patents. Machine Design, vol. 1, no. 3, Nov. 1929, pp. 53–59, 3 figs. Description of constant-clearance valve mechanism which has been granted A. V. D. Willgoos for Pratt and Whitney Aircraft Co., Hartford, Conn.; means is given for maintaining constant valve clearance to prevent differential expansion due to variance in degrees of temperature attained by parts of valve actuating mechanism and other parts of engine; patent is also described for bearings for rotating or oscillating methods granted to H. C. Harrison; other machinery patents are described.

AIRPLANE PROPELLERS

Variable-Pitch. Variable-Pitch Propellers, F. W. Caldwell. Soc. Automotive Engrs. Jl., vol. 25, no. 6, Dec. 1929, pp. 656–664 and (discussion) 664–666, 16 figs. Effect of camber ratio and of angle of attack on speed at which burble occurs; efficiency of propellers as static-thrust producers; method of momentum to compute thrust and application of adjustable-pitch propellers to supercharged engines; causes of forces required to operate control adjustments; method of elastic-stress analysis; with increase of propeller-tip speeds and engine horsepower, aerodynamic advantages of controllable-pitch propeller become more important.

AIRPLANES

Brakes. The Sikorsky Multiple Disc Brake. U. S. Air Services, vol. 14, no. 12, Dec. 1929, p. 72, 1 fig.; see also Aero Digest, vol. 15, no. 6, Dec. 1929, p. 168, 1 fig. Description of Sikorsky multiple-disk brake which, being applied to all Sikorsky amphibians, enables them to land within space of 300 ft.; there are three stationary plates outside and inside plates having brake lining riveted to one side only, while center plate has brake lining riveted on both sides.

Gliders, Use of. On Motorless Flying. Aeroplane (Lond.), vol. 37, no. 19, Nov. 6, 1929, pp. 1089–1090, 1092, 1094 and 1096, 9 figs. Use of gliders for sport and also for purpose of scientific research is discussed; comparison with bird flight; opinions of C. Lougheed considered; it has been shown in Germany that serious gliding experiments, especially in study of gliding angles, can be made with help of ordinary airplane.

Maneuverability. Test for Maneuverability (Essai sur la maniabilité), A. Volmerange. Aéronautique (Paris), vol. 11, no. 125, Oct. 1929, pp. 333–338. Theory of maneuverability is discussed; it is shown that this problem can be handled with same precision as parts of construction; first degree is possibility of passing from condition of normal flight to any other anticipated condition; second degree is facility in preceding maneuver, and quality with which safety of control is approached; third degree is rapidly in that maneuver; fourth degree is possibility of passing from abnormal condition of flight supposed accidental to normal condition of flight.

Rocket. Opel Sander Rocket Plane, E. P. A. Heinze. Aero Digest, vol. 15, no. 5, Nov. 1929, p. 158, 2 figs. Description of rocket plane of glider type with short fuselage which terminates just aft of cockpit with magazine containing spaces for rockets, each 18 in. long and 3 in. in diameter; elevators and two fins and rudders are fixed at end of girder structure extending rearward from parasol type wing and fuselage; each rocket when discharged gives propulsive pressure of 110 lb.

Speed. The Economic Speed-Weight Relation in Air Transportation, E. P. Warner. Soc. Automotive Engrs. Jl., vol. 25, no. 6, Dec. 1929, pp. 635–640, 6 figs. Relations of payload to engine horsepower, initial cost of airplane and engine, costs per pound of payload and per passenger-mile, and value of time saved by greater speed; five means for securing higher crusing speed; seeking to operate at cruising speeds of more than 1.8 times minimum flight speed does not appear economically advisable at present; increasing crusing speed depends on use of engines, engine combinations, maintenance methods and large smooth airports.

Spinning Characteristics. Spinning, J. D. Blyth. Flight (Lond.), vol. 21, no. 1092, Nov. 29,

1929 (Aircraft Engr. Supp.), pp. 84–87, 9 figs. Aeroplane in free flight; wing characteristics have greatest effect on initial tendency to spin; final rate of spin will be influenced principally by combination of wing characteristics, distribution of weight along fuselage, and fin and rudder area; centrifugal couple will be greater in case of thin section; type of machine most likely to develop vicious variety of spin is thin-winged biplane of low aspect ratio, with negative stagger and small gap.

Tail Spins, H. A. Sutton, Aviation, vol. 27, no. 25, Dec. 21, 1929, pp. 1196–1202, 9 figs. Way in which changes in design affect spinning characteristics of airplane is discussed; limitations of wind-tunnel tests; full-scale spinning experience should be available for study; proportioning elevators; effect of mass distribution along wing span; if lift curve could be made to remain at approximately its maximum considerable range of angle of attack followed by gradual reduction in lift forces, probability of spinning would be greatly reduced; designer not yet assured of correcting spinning difficulties by employment of slots.

Stability. Balancing and Stability of Airplanes (Centrage et stabillité des avions), M. Guibert, Aéronutique (Paris), vol. 11, no. 125, Oct. 1929, pp. 339–346, 10 figs. Description of method permitting easy construction of curves for practical discussion of balancing and static stability of airplane in particularly simple fashion; method has advantage of permitting construction of curves independent of depth of centering; application to normal flight; flight on back, setting for limited diving; during flight before point of transition; partial inversion of controls.

Longitudinal Stability for Very Large Airplanes, A. Klemin. Aviation Eng., vol. 2, no. 12, Dec. 1929, pp. 9–11, 1 fig. Problem of longitudinal stability of airplane is discussed taking damping into consideration; suggestion is made that large machines can be short coupled, have their weight concentrated along longitudinal axis, and have large static stability secured mainly by constant center of pressure, or other methods independent of product of tail area.

Wing Flutter. The Torsional Strength of Wings, C. P. Burgess. Nat. Advisory Committee for Aeronautics—Report, no. 329, 1929, 14 pp., 5 figs. Simple method for calculating position of elastic axis of wing structure having any number of spars; strong drag bracing near top and bottom of wing greatly increases torsional strength; analytical procedure for finding contribution of drag bracing to torsional strength and stiffness; mathematical theory of forces producing flutter is not yet sufficiently far advanced to determine by direct calculation critical air speed at which flutter will commence.

AIRSHIPS

R100. H. M. Airship R100. Engineer (Lond.), vol. 148, no. 3856, Dec. 6, 1929, pp. 604–605, 4 figs. partly on p. 608. R100, built at Howden, Yorkshire, is fitted with gasoline engines which is likely to result in flights being confined to cool climates, including Transatlantic voyages equipment consists of six Rolls-Royce "Condor" III. B engines, each developing 660 hp.; passengers and crew are accommodated in three-decked compartment slung inside hull at point forward of its maximum diameter; length 709 ft.; max. diam. 133 ft., over-all height, 135 ft. gas capacity is over 5,000,000 cu. ft.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.

Anti-Corrosive. Properties of Corrosion-Resisting Alloys, P. S. Menough. Blast Furnace and Steel Plant, vol. 17, no. 11, Nov. 1929, pp. 1648–1651 and 1655, 3 figs.; see also Heat Treating and Forging, vol. 15, no. 11, Nov. 1929, pp. 1437–1440, and 1450, 3 figs. Selection of compositions and methods in fabricating parts involves familiarity with technique that is gained only through experience; effect of adding chromium to steel up to stainless analysis and beyond; influence of carbon; some weaknesses of high-chromium steels; resistance to high temperature and corrosion; welding and machining; abrasion resistance.

Bearing Metals. See BEARING METALS.

Magnesium. See MAGNESIUM ALLOYS.

ALUMINUM ALLOYS

Castings. Cast Aluminum Alloy That Compares With Die Castings, L. H. Fawcett. Iron Age, vol. 124, no. 26, Dec. 26, 1929, pp. 1722–1724, 4 figs. Description of unusual practice at United States Naval Gun Factory for casting aluminum alloys; castings are made in sand and require minimum machining; metal and wooden patterns used; molding of chute casting; typical case; closing mold and pouring; machining and assembling; casting made with tolerances approaching die castings.

Properties. Brinell Hardness, Elastic Limits, and Tensile Strength of Commercial Aluminum Alloys (Brinellhaerte, Elastizitaetsgrenze und Zugfestigkeit verguetbarer Aluminium legierungen), H. Bohner. Zeit. fuer Metallkunde (Berlin), vol. 21, no. 11, Nov. 1929, pp. 387–389, 1 fig. Influence of different stresses and duration of stress on Brinell hardness; formula is proposed for calculation of Brinell hardness of aluminum-copper alloys from tensile strength and elastic limits; according to author, further tests are deemed necessary.

ARMOR PLATE

Machining. An Armor Plate Ordeal for Tungsten-Carbide, H. A. Ingram. Am. Mach., vol. 72, no. 2, Jan. 9, 1930, pp. 39–42, 6 figs. Description of difficult and unusual job recently completed by Hull Construction Department at United States Navy Yard, Puget Sound; machining face-hardened nickel-steel armor plate by utilizing peculiar cutting properties of tungsten-carbide after ordinary cutting tools had repeatedly failed; comparison of methods for cutting armored tube shown.

ASH HANDLING

Gas Plants. The Krefeld Practice of Ash Handling (Ueber die Krefelder Aschenaufbereitung), K. Beuthner. Gas- und Wasserfach (Munich), vol. 72, no. 38, Sept. 21, 1929, pp. 927–928, 2 figs. Features of dry method of ash handling including description of Ullrich patented electromagnetic separator for recovery of fuel from combustion residues; results of seven years' operating experience.

AUTOMOBILE ENGINES

Crankshafts—Torque. Engine Torque Analysis, H. A. Huebotter. Soc. Automotive Engrs.—Jl., vol. 25, no. 6, Dec. 1929, pp. 641–653 and discussion 653–655, 19 figs. Analytical method of investigating engine torque are given accompanied by number of sample analyses; method easier to apply to complete analysis and is adaptable to investigations that cannot be made by graphical method; in discussion is given outline of mathematics required to follow analysis presented.

Cylinder Heads. Ricardo Cylinder Head Tested. Autocar (Lond.), vol. 63, no. 1769, Sept. 27, 1929, p. 605, 3 figs. Description and report upon efficiency of Ricardo cylinder head; in the head most of combustion space is over valves and not above piston; head is formed to provide comparatively restricted passage between combustion chamber and cylinder, while there is a narrow space left between the cylinder head and the piston crown when the piston is at top of stroke.

Testing. Preheating of Mixture in Automobile Engines (Gemischvorwaermung bei Motoren fuer Kraftfahrzeuge), G. Becker. V.D.I. Zeit. (Berlin), vol. 73, no. 47, Nov. 23, 1929, p. 1674, 1 fig. Results of tests carried out by author on different types of engines to determine conditions which heating of carburetors and mixture must fulfill from standpoint of fuel economy. Abstract of published report.

AUTOMOBILES

Amphibian. An Amphibian Motor Car, H. Zabinski. Eng. Progress (Berlin), vol. 10, no. 12, Dec. 1929, p. 328, 3 figs. Vehicle put into commission by German Admiralty; depth of water on Watten varies on average between 2 ft. 4 in. and 2 ft. 8 in.; Voran Automobilbau-Aktiengesellschaft, Berlin designed drive to wheels in accordance with front-wheel drive patents; Hoppe and Kroos G. m. b.H., of Cuxhaven, built vehicle; it has appearance of motor boat of comparatively deep draft; 22.3 ft. in length and 6.9 ft. in breadth; weight, 4 tons.

Shimmying. Wheel Wobble, A. G. D. Clease. Autocar (Lond.), vol. 58, no. 1779, Dec. 6, 1929, pp. 1222–1224, 5 figs. Review of latest available data concerning wheel wobble; discussion of what it is, how it is caused, and how it may be cured; it was found that wobbling is governed by speed and by position of axle; play in steering gear must be as small as possible, and measured at wheels must not exceed 1 to 1½ degrees.

Springs and Suspensions—Testing. Measure of Shock Absorber Performance Developed as Index of Automobile Spring Action Under Deflection, E. W. Weaver. Automotive Industries, vol. 61, no. 24, Dec. 14, 1929, pp. 870–872, 11 figs. Measure of spring control performance for experimental or practical inspection and use; instrument shows direction and magnitude of oscillations during entire cycle, giving picture of movement; difference of opinion as to where and how resistance should be applied in spring movement cycle; rate of travel of spring in these tests too slow to bring out actual resistance caused by upward thrusts from road at high speed.

B

BEARING METALS

Thermit. A New Product of Bearing-Metal Research. Metal Industry (Lond.), vol. 35, no. 19, Nov. 8, 1929, pp. 441–442. Description of alloy bearing metal known as Thermit or Universal Bearing Metal, which had been produced by T. Goldschmidt, A.G., Essen, in connection with G. von Hanffstengel; structure of Thermit comprises uniformly distributed hardening bodies bedded in plastic eutectic ground-mass which is rich in lead; through high softening point of Thermit alloys, favorable hardness conditions are maintained; slipperiness of Thermit investigated by process of von. Hanffstengel; casting of Thermit. Abstracted from Technische Blaetter, Aug. 4.

BLAST FURNACES

Germany. Blast-Furnace Plant of Fried. Krupp Company at Essen-Borbeck (Das Hochofenwerk der Fried. Krupp Aktiengesellschaft in Essen-Borbeck), R. Dietrich. Kruppsche-Monatschefte (Essen), vol. 10, no. 139, Oct. 1929, pp. 139–159, 29 figs. Plant and auxiliary machinery are fully described and illustrated; in addition to numerous photographs in text, map of layout of works, plans and elevations of various machines, and elevation of one of blast-furnaces are given.

Practice. Modern Blast Furnace Theory and Practice, R. H. Sweetser and S. P. Kinney. Iron and Steel Eng., vol. 6, no. 11, Nov. 1929, pp. 575–579, 2 figs. Adoption of measure of performance of blast furnace has indirectly resulted in almost doubling daily output of pig iron in stacks of given height and bosh diameter; cleaning blast-furnace gas; movement of hot metal; adoption of three-shift day; merchant blast furnaces.

BOILER FURNACES

Water-Cooled. Determination of Circulating Speed in Cooling-Wall Tubes (Bestimmung der Umlaufgeschwindigkeit in Kuehlwandrohren), W. Boie. Feuerungstechnik (Leipzig), vol. 17, no. 21–22, Nov. 15, 1929, pp. 232–235, 9 figs. Increase in efficiency of boilers demands water-cooled combustion chamber walls; their increasing use necessitates paying of greater attention to circulation in cooling tubes; method of determining steam-water mixture and velocity is described.

BOILER TUBES

Heat Transmission in. Determination of Heat-Transfer Coefficients by Means of Diffusion Tests (Bestimmung von waermeuebergangszahlen durch Diffusionsversuche), W. Lohrisch. Forschungsarbeiten auf dem Gebiete des Ingenieurwesens (Berlin), no. 322, 1929, p. 46–49. Heat transfer of flowing gases in tubes arranged perpendicularly to direction of flow was investigated by Thoma's method of determining heat-transfer coefficients from diffusion phenomena; heat-absorption tests were carried out on rotating single tubes (Atmos boilers); heat-transmission coefficient is established as function of air velocity and suggestions are made for improving heat transfer.

Heat Transfer in Water Tubes (Waermeuebergang in Wasserrohren), F. Jaklitsch. Waerme (Berlin), vol. 52, no. 46, Nov. 16, 1929, pp. 851–954. As results of tests carried out by Soennecke, it is shown that transmission in water tubes can be determined by formula already developed for air and steam; this fact suggests possibility of existence of single heat-transfer law, independent of substance or its aggregate state.

BOILERS

Design. Utilization of Heat Radiation as Means of Reducing Cost of Boiler Plants (Die Ausnutzung der Waermestrahlung als Mittel zur Verbilligung von Kesselanlagen), W. Schultes. Waerme (Berlin), vol. 52, no. 49, Dec. 7, 1929, pp. 939–944, 12 figs. Theory of radiation boiler is discussed and diagrams are presented to illustrate heat transfer by radiation, and contact; examples are given of two kinds of boilers utilizing heat radiation, namely water-tube with cooled furnace and fire-tube boiler with pulverized-coal furnace and no ignition chamber.

Gas-Producer. Wignal-Wollaston Producer. Engineer (Lond.), vol. 148, no. 3858, Dec. 20, 1929, p. 672, 1 fig. Boiler is combination of vertical and horizontal types; arrangement combines spacious firebox of vertical boiler with long flue travel of horizontal boiler, which, it is claimed, enables maximum of heat to be abstracted from products of combustion.

Manufacture—Welding. Welding of Boilers, Pressure Vessels and Steam Lines, C. W. Obert. Power, vol. 70, no. 23, Dec. 3, 1929, pp. 904–905. Outline of present status of fusion welding and attitude of A.S.M.E. Boiler Code

Committee and other authorities. Abstract of paper read before Int. Acetylene.

Operation, Load Distribution in. A Method of Loading Boilers for Maximum Fuel Economy, B. M. Thornton. Engineering (Lond.), vol. 128, no. 3336, Dec. 20, 1929, pp. 796–797, 5 figs. Boiler-house superintendents are faced with problem of so distributing load among boilers that each unit is working at its most economical output, and author draws attention to one satisfactory method of solving this problem; by application of principle outlined he believes that considerable fuel saving might be effected in number of boiler houses; all boilers are considered to be connected to common-steam-collecting main.

Water-Tube. High-Capacity Boilers at Low Cost (Der billige Hochleistungskessel), O. Wirmer. Waerme (Berlin), vol. 52, no. 48, Nov. 30, 1929, pp. 904–908, 4 figs. In view of unfavorable business conditions in Germany, and present lack of funds, possibilities of developing cheaper design of water-tube boilers were studied with result that new type of vertical-tube boiler with two drums has been developed which is capable of maximum loads.

Model Tests on Water Circulation in Vertical-Tube and Inclined-Tube Boilers (Modellversuche ueber den Wasserumlauf in Steil- und Schraegrohrkesseln), K. Cleve. Forschungsarbeiten auf dem Gebiete des Ingenieurwesens (Berlin), no. 322, 1929, p. 1. Water-circulation theory of Muenzinger was experimentally examined and influence of heating, tube diameter, incline, and length of tube, etc., on water circulation was investigated; flow resistance of water during passage through tube was determined and calibrating curves developed for instruments used in measuring velocity of flow in boiler tubes.

BORING AND TURNING MACHINES

Giant. A Giant Boring and Turning Mill, H. Vogler. Eng. Progress (Berlin), vol. 10, no. 12, Dec. 1929, pp. 309–312, 3 figs. See also Machy. (Lond.), vol. 35, no. 894, Nov. 28, 1929, pp. 275–276, 1 fig. Large boring and turning mill with 39 ft. diam. of table, length of cross rail 72 ft., for maching of rotors and stators, etc. of large turbine units, made by Schiess-Defries for J. M. Voith, machine builders of Heidenheim, Germany; pieces of 200 tons can be machined; capacity of main motor is 250 hp.; traveling speed of tools 8.2 ft.

Vertical. Vertical Boring and Turning Machine with Table of 12 m. Diameter (Tour-carrousel vertical à plateau de 12 metres de diamètre). Génie Civil (Paris), vol. 95, no. 20, Nov. 16, 1929, pp. 477–480, 6 figs. Machine is built by Schiess-Defries in Duesseldorf for Voith in Heidenheim and will be used for working large hydraulic turbine parts, such as rotors, stators, etc.; pieces up to 18 m. diam. and weighing 700 tons can be machined on lathe, of which constructional details are given.

C

CAMS

Design. Cam Design from the Standpoint of Stress Analysis, J. Flodin. Machine Design, vol. 1, no. 4, Dec. 1929, pp. 18–23, 10 figs. Force to be transmitted is important consideration in design in addition to movement of follower; force factors to consider are discussed.

CARBON DIOXIDE

Thermal Properties. Thermal Characteristics of Carbon Dioxide in Gaseous, Liquid, and Solid Condition (Die thermischen Eigenschaften der Kohlensaeure im gasfoermigen fluessigen und festen Zustand), R. Plank and J. Kuprianoff. Zeit. fuer die gesamte Kaelte-Industrie (Munich), vol. 1, no. 1, 1929, 64 pp., 17 figs. partly on supp. plates. Recapitulation of previous works; analysis of equilibrium curves, specific volume; latent heat, enthralpy and entropy; gas tables and diagrams are given. Bibliography.

CASTINGS

Cleaning. The High-Pressure Water-Jet Method of Cleaning Castings, H. Kalpers. Eng. Progress (Berlin), vol. 10, no. 12, Dec. 1929, pp. 314–315, 1 fig. In working with installation of Badische Maschinenfabrik, most favorable thickness of jet was found to be obtained with nozzle diameter of between about 0.20 and 0.32 in., irrespective of pressure used; working pressure is between 75 to 100 atmos., 1050 and 1400 lb. per sq. in.; at Lanz plant, pressure of 1.050 lb. per sq. in. is employed, diameter of nozzles being between 0.2 and 0.26 in.

Tests of a Wet Cleaning Plant (Versuche an einer Nassputzanlage), U. Lohse. Giesserei (Duesseldorf), vol. 16, no. 49, Dec. 6, 1929, pp. 1137–1144, and (discussion) 1144–1145, 17 figs. Description of high-pressure wet-cleaning plant and process employed; determination of quantity of water emitted with different nozzle diameters; determination of cleaning time required; influence of nature of molding material on cleaning time.

X-Ray Analysis. X-Ray Analysis in Foundry Practice (Roentgentechnik in der Geisserei), W. B. Bartels. Giesserei-Zeitung (Duesseldorf), vol. 26, nos. 22 and 23, Nov. 15 and Dec. 1, 1929, pp. 632–634 and 666–672, 29 figs. Notes of use and advantages of X-ray analysis of castings; considerations of cost; details of chemical and physical crystallography; five fundamental possibilities of fine structural analysis are enumerated.

CAST IRON

High-Test. Production of High-Strength Cast Iron. Machy. (N. Y.), vol. 36, no. 4, Dec. 1929, p. 302. Description of Meehanite, which is produced by refinement of ordinary process employed in making semi-steel; ultimate strength and yield point of ordinary cupola Meehanite metal said to be 46,000 lb. per sq. in.; effect of heat treatment on Meehanite; methods of adding nickel to cast iron; Gunite, wear-resisting iron.

Properties. New Theories of the Mechanical Properties of Cast Iron (Neuere Anschauungen ueber die mechanischen Eigenschaften des Gusseisens), A. Thum. Giesserei (Duesseldorf), vol. 16, no. 50, Dec. 13, 1929, pp. 1164–1173 and (discussion) 1173–1174. Notch effect of graphite veins and its influence on strength and elasticity of cast iron; evaluation of coefficients of deflection in bending test; ductility and durability; comparison of cast iron and steel.

COAL CARBONIZATION

Low-Temperature. Low-Temperature Carbonization in Germany, D. Brownlie. Iron and Coal Trades Rev. (Lond.), vol. 119, no. 3225, Dec. 20, 1929, pp. 939–940. Description of Tormin process for making hard, dense, smokeless fuel from coking bituminous coal dust and fines, by heating under low-temperature conditions, 430 to 650 deg. cent., subjecting charge at same time to strong mechanical compression.

Scientific Developments in Steam-Driven Power Station Practice, D. Brownlie. Machy. Market (Lond.), nos. 1513, 1514, 1515, and 1516, Nov. 1, 8, 15, and 22, 1929, pp. 1005–1006, 1029–1030, 1051–1052, 1073–1074, and 1076, 6 figs. Nov. 1: Combined low-temperature carbonization, gasification, and combustion discussed; one aspect of future development of power-station practice according to entirely different methods; valuable by-products of coal; sulphur problems. Nov. 8: Details of Babcock, Pintsch, Hanl, and Hereng processes. Nov. 15: KSG process. Nov. 22: Kwollaston process; gas-fuel system; MacLaurin and other processes. Paper presented before Instn. Mech. Engrs.

COAL HANDLING

Loaders. Bucket Loader Performs Threefold Operation, J. Rolfe. Matls. Handling and Distribution, vol. 3, no. 3, Dec. 1929, pp. 38 and 86, 2 figs. Bucket loader described is self feeding and screens and feeds 50 bushels in three minutes; is also used for turning oxide.

CONVEYORS

Belt. An Improved Troughed Belt Conveyor. Cassier's Indus. Mgmt. (Lond.), vol. 16, no. 12, Dec. 1929, pp. 418–420, 4 figs. Description of type which can be easily dismantled and reassembled, and which can be employed above and below ground.

Gravity. Gravity Conveyors Facilitate the Assembly of Portable Tools. Am. Mach., vol. 71, no. 25, Dec. 19, 1929, pp. 1004–1005, 7 figs. Seven pictures from Independent Pneumatic Tool Co. which show how these conveyors, in conjunction with chain elevators and monorail feed-ins, link assembly with stock and shipping.

Monorail. Monorail—A Flexible Servant. Can. Machy. (Toronto), vol. 40, no. 25, Dec. 12, 1929, pp. 57–58, 60, 62–63, 13 figs. Various applications of monorail in industrial plants are shown in 13 halftones each accompanied by brief description.

COOLING TOWERS

Characteristics of. Characteristics of Water Coolers (Quelques Propriétés des Refrigérants d'Eau), M. Bonnemort. Chaleur et Industrie (Paris), vol. 10, no. 113, Sept. 1929, pp. 428–432, 5 figs. General discussion; curves showing temperature differences and presentation of general characteristics in graphs.

Diesel Plants. Cooling Towers for Diesel Plants, L. A. Pease. Power, vol. 70, no. 23, Dec. 3, 1929, pp. 886–887, 2 figs. Discussion of types of water-cooling towers; atmospheric towers used in majority of cases; diagrammatic layout of commonly used atmospheric cooling tower.

COPPER

Annealing. Anomalies of Annealing After Cold Hardening of Copper and Brass (Anomalies du recuit apres écrouissage du cuivre et des laitons), F. Eugene. Société d'Encouragement pour l'Industrie Nationale—Bul. (Paris), vol. 128, no. 5, May 1929, pp. 361–379, 20 figs. Study of anomaly described by P. Nicolau which affects not only hardness but fitness for swaging characterized by deflection before rupture in Erichsen test, and, in less degree, elongation; dilatometric tests effected by differential dilatometer of Chevenard show that phenomena of annealing copper and brass is sufficiently different.

COUPLINGS

Flexible. The Steel-Shaw Flexible Coupling. Engineering (Lond.), vol. 128, no. 3332, Nov. 22, 1929, p. 689, 2 figs. It has been designed to allow for amount of misalignment which appears to be inevitable in even most accurate of erection operations, flexible elements of coupling are enclosed in split casing, which contains oil, and rotates with them.

Pulvis. Construction and Performance of the Pulvis Coupling (Nagot om pulviskopplingens konstruction och driftsegenskaer), B. H. Lundborg. Teknisk Tidskrift (Stockholm), vol. 59, no. 46, Nov. 16, 1929, pp. 146–150, 8 figs. Coupling is designed to overcome starting torque an overloading of machinery; works on principle that powdered material transmits power from driving to driven shaft; found satisfactory for 230 hp. at 300 r.p.m.

CRANES

Caterpillar. Crawler Crane Around Plant Yard Saves $2000 a Year, H. A. Scribner. Matls. Handling and Distribution, vol. 3, no. 3, Dec. 1929, pp. 40 and 55, 3 figs. Crane described consists of crane with special dog leg boom; latter has two cable sheaves, one at boom point at radius of 20 ft. 6 in., other at 15-ft. radius; short-radius sheave is used for handling heavy dies, while long radius is used generally for sheet and bat steel, scrap metal, turning borings and coal.

Control. Easy Crane Control by Push Buttons. Iron Age, vol. 124, no. 26, Dec. 26, 1929, pp. 1740–1741, 1 fig. Description of 40-ton riveting crane in plant of Lasker Iron Works, Chicago; accurate sporting for riveting work, saving in labor increase in production reported; independent push-button control stations, one at control point of each poll riveter are interlocked so that only one set of push buttons can be used at one time.

CUPOLAS

Mixers. Some Notes on Cupola Receivers, M. G. Woods. Foundry Trade Jl. (Lond.), vol. 41, no. 691, Nov. 14, 1929, pp. 353–354 and 356, 6 figs. Various types of receivers for cupolas are described including, Whiting cupola and receiver, jolting receivers, Hurst's oil-fired receiver, outside and inside receivers; advantages and disadvantages of receivers outlined.

Refractories for. Cupola Refractories, C. Presswood. Foundry Trade Jl. (Lond.), vol. 41, nos. 692 and 693, Nov. 21 and 28, 1929, pp. 369–371, 376 and (discussion) 389–390. Nov. 21: Cost of cupola operation reflected in finished materials; temperature conditions; temperature fluctuations; influence of fluxes; neutral linings; destruction by abrasion; influence of furnace gases; brick linings; materials available; spalling; siliceous bricks; neutral bricks; rammed linings; patching materials. Nov. 28: Cupola refractories and cost of castings; glazing of refractories; effect of continuous working.

CUTTING TOOLS

Tungsten Carbide. An Armor Plate Ordeal for Tungsten-Carbide, H. A. Ingram. Am. Mach., vol. 72, no. 2, Jan. 9, 1930, pp. 39–42, 6 figs. Description of difficult and unusual job recently completed by Hull Construction Department at United States Navy Yard, Puget Sound; machining face-hardened nickel-steel armor plate by utilizing peculiar cutting properties of tungsten-carbide after ordinary cutting tools had repeatedly failed; comparison of methods for cutting armored tube shown.

D

DIE CASTING

Aluminum-Alloys. Effect of Pores on Strength of Die Castings (Der Einfluss von Poren auf die Festigkeit von Spritzguss), L. Frommer, W. Kuntze, and G. Sachs. V.D.I. Zeit. (Berlin),

vol. 73, no. 45, Nov. 9, 1929, pp. 1609–1612, 4 figs. Report on X-ray study and mechanical tests of aluminum die castings, made at German Bureau for Materials Testing and Kaiser Wilhelm Institute for Physical Chemistry and Metallurgical Research; authors estimate effect of blowholes in reducing specific strength of casting at not much over 10 per cent.

Zinc-Base. Strength of Zinc Base Die Castings, R. M. Curts, Iron Age, vol. 124, no. 25, Dec. 19, 1929, pp. 1655–1658, 13 figs. Remarkable improvement which has been made to physical properties of zinc-base die-casting alloys; improvement has been large recently; gravity and pressure methods compared; types and relative merits of alloys available.

DIES

Stamping. Metal Stamping Dies, E. E. Clark. Metal Stampings, vol. 2, no. 11, Nov. 1929, pp. 865–870, 9 figs. Typical die layout; planning sequence of stamping and forming operations; comparatively estimating die costs.

DIESEL-ELECTRIC POWER PLANTS

Hotels. Hotel New Yorker Diesel Generator Now Operating. Oil Engine Power, vol. 7, no. 12, Dec. 1929, pp. 682–686, 8 figs. Use of Diesel engines in Hotel New Yorker power plant is based on ability to improve balance between electric power load and heating load; Diesel engine able to carry summer electric load; charts illustrating heat saving creditable to Diesel; brief description of Davis heater which contributes to Diesel economy.

DIESEL ENGINES

Automotive. History of Light Diesel Engines, E. C. Magdeburger. Soc. Automotive Engrs. Jl., vol. 25, no. 6, Dec. 1929, p. 698. Development of high-speed oil-engines is discussed; fluid injection saves weight; Diesels on motor-coaches; peculiarity of Packard engine is that single valve serves both for exhaust and inlet.

Marine. The Large Diesel Engine, H. Becker. Brit. Motor Ship (Lond.), vol. 10, no. 117, Dec. 1929, pp. 353–355, 8 figs. Special types of Diesel engines suitable for marine purposes are discussed; airless-injection, fuel consumption, gearing and comparative weights and sizes with special reference to M.A.N. engines. Supplement to article published in July 1929 issue of same journal.

The Marine Diesel Engine, H. Blache. Brit. Motor Ship (Lond.), vol. 10, no. 115, Oct. 1929, pp. 247–251, 11 figs. Details of new Burmesiter and Wain double-acting two-stroke type; advantage of design is that main piston does not cut off and uncover exhaust ports, subjecting piston surface to great heat from rebounding of exhaust gases from remainder of cylinders, as is case with other types of two-stroke engines. Extract from paper read on occasion of Centenary of Royal Technical University, Copenhagen.

Pulverized-Fuel. The Use of Pulverized Coal in Internal-Combustion Engines (Kohlenstaub als Triebmittel fuer Brennkraftmaschinen), H. Jentzsch. Werft-Reederei-Hafen (Berlin), vol. 10, no. 20, Oct. 22, 1929, pp. 409–411, 3 figs.; see also brief translated abstract in Mar. Engr. and Motorship Bldr., vol. 52, no. 627, Dec. 1929, p. 504. Original work of Diesel has been continued by Pawlikowski and fairly successful pulverized-coal engine developed; author emphasizes necessity for greater investigation of pulverized-fuel motor and points out that its ultimate development will admit of cost of running Diesel engine as against oil to be reduced to one quarter.

E

ELECTRIC FURNACES

Induction. Induction Furnaces. Engineer (Lond.), vol. 148, nos. 3858 and 3859, Dec. 20 and 27, 1929, pp. 652–654 and 680–682, 17 figs. Furnaces are of two kinds, standard frequency induction and those which employ high-frequency currents; while former is limited by metallurgical considerations and problems of electrical design high-frequency furnace removes these limitations and gives wider field to metallurgical research, and to melting of metals having high melting points; details of Ajax Northrup and Ajex Wyatt furnaces; review of research on coreless induction furnaces; examples of furnaces and auxiliary equipment are illustrated.

ELECTRIC HEATING

Thermal Storage. The Heating of Buildings Electrically by Means of Thermal Storage, S. E. Monkhouse and L. C. Grant. Instn. Elec. Engrs.—Advance Papers, Sept. 19, 1929, 9 pp., 5 figs. Authors advocate more extended use of electrical heating by adopting thermal storage, thus enabling energy to be used during off-peak hours; they contend that such a system is economical to operate, and they show that, for large buildings, electric heating can compete with systems employing other forms of fuel.

ELECTRIC WELDING

Machines, Automatic. Automatic Arc Welding Machine (Lichtbogen-Schweissautomat). V.D.I. Zeit. (Berlin), vol. 73, no. 49, Dec. 7, 1929, (Supplement), p. 78, 2 figs. Particulars of machines made by A. E. G. for welding of tanks, pipe, shafts, etc.

Machinery. Arc Welding in Manufacture of Electric Machinery (Lichtbogenschweissung im Bau elektrischer Maschinen), C. Ritz. V.D.I. Zeit. (Berlin), vol. 73, no. 49, Dec. 7, 1929, pp. 1740–1741, 9 figs. Examples are given showing wide application of electric welding to machinery manufacture; conditions governing successful welding practice are briefly stated.

F

FLOW OF AIR

Measurement. Measurement of Air Flow, E. Ower. Instruments, vol. 2, nos. 10 and 12, Oct. and Dec., 1929, pp. 347–358 and 443–454, 7 figs. Theoretical mathematical discussion regarding general principles of pressure-tube anemometer; flow of air in pipes; resistance of pipe to motion of fluid along it; characteristics of flow in pipes; turbulent flow in pipes.

FLOW OF FLUIDS

Rotating Tubes. Flow Phenomena in Revolving Tubes (Stroemungserscheinungen in rotierenden Rohren), F. Levy. Forschungsarbeiten auf den Gebiete des Ingenieurwesens (Berlin), no. 322, 1929, pp. 18–45, 22 figs.; see also abstract in V.D.I. Zeit. (Berlin), vol. 73, no. 42, Oct. 19, 1929, p. 1512. Purpose of investigations was to find means of improving efficiency of diffusers; tests were carried out on rotating cylindrical tubes such as are used in atmos boilers and rotating cylindrical tubes such as are used in atmos boilers and rotating diffusers; most important result is fact that pressure drop in straight tubes is greatly reduced by influence of wall rotation; transformation of flow energy into kinetic energy in diffuser is studied.

Theory. New Theory of Flow (Neue Wege in der Stroemungslehre), J. Maercks. Glueckauf (Essen), vol. 65, no. 36, Sept. 7, 1929, pp. 1234–1241, 11 figs. According to new theory described, friction resistance is in all flow phenomena a function of Reynolds coefficient; elementary explanation and derivation of this coefficient is given and its application to flow in tubes, nozzles, and orifices is explained.

FLOW OF STEAM

Measurements. Precision of Nozzle Measurements of Steam Flow in Acceptance Testing (Ueber die Genauigkeit von Dampfmessungen mittels Duesen bei Abnahmversuchen), M. Ten Bosch. Schweizerische Bauzeitung (Zurich), vol. 94, no. 17, Oct. 26, 1929, pp. 209–212, 7 figs. Discussion of precision based on experimental study by Witte; precise measurements of pressure differences and temperatures; nozzles can be calibrated by using cold water; author concludes that in practice allowance should be made for errors up to 2 per cent.

FORGE SHOPS

Duff-Norton Mfg. Co. The Duff-Norton Manufacturing Company. Heat Treating and Forging, vol. 15, no. 12, Dec. 1929, pp. 1628–1630, 7 figs. Description of forge shops of Duff-Norton Manufacturing Co., Pittsburgh, Pa.; 19 forge heating furnaces of overfired box type each fitted with two Gilbert and Barker combination furnaces for use with either gas or oil.

FORGINGS

Steel, Heat Treatment of. A Microscopic Study of Improperly Heated Forgings, A. S. Jameson. Am. Soc. Steel Treating—Trans., vol. 17, no. 1, Jan. 1930, pp. 81–89, 20 figs. It is purpose of paper to illustrate few of defects which result from uncontrolled heating of steel prior to hot working or forging, and in doing this show how valuable a tool microscope is in determining exact occurrence of these flaws.

Upset. Development of Upset Forgings, W. E. Crocombe. Iron Age, vol. 124, no. 23, Dec. 5, 1929, pp. 1513–1515, 2 figs. Many advantages of upset method of forging are discussed and its development traced; saving of one-fifth in weight and great improvement in output; uniform grain conditions give higher strength; much great production obtained; upset method eliminates tong holds; plea for adequate cost analysis.

FURNACES

Melting, Pulverized Coal. Uses Rotary Foundry Melting Furnace. Iron Age, vol. 124, no. 24, Dec. 12, 1929, p. 1586. Description of furnace of unique design called Brackelsburg which has recently been put into operation in Germany in production of high-quality gray and malleable castings; furnace is horizontal cylindrical, shell, rotating during melting and superheating and fired with powdered coal; rate of revolution slow during melting. From Publication no. 131 of Kaiser Wilhelm Institute fuer Eisenforschung.

G

GAGES

Electric. The Electric Gage, A. V. Mershon, J. W. Matthews and B. C. Waite, Jr. Gen. Elec. Rev., vol. 32, no. 12, Dec. 1929, pp. 674–675, 3 figs. Instrument is independent of human sense of touch; simple and rapid to manipulate; amplification factor is 10,000; electric gage has been developed to meet for accurate gaging device that has but minimum of moving parts and that will permit routine gaging operations to be conducted with great rapidity.

GEAR CUTTERS

Crown-Gear Hobbing. Crown Gear Hobbing Fixture for Turret Lathe, O. S. Marshall. Machy. (N. Y.), vol. 36, no. 4, Dec. 1929, pp. 297–298, 5 figs. Description of fixture of unusual design applied to Hartness flat turret lathe for; hobbing teeth on crown-tangent-tooth gear basically fixture is application of Hartness chasing attachment to driving of hob.

GEARS

Non-Metallic, Manufacture of. Design of Textolite Gears, H. D. Randall. Am. Mach., vol. 71, no. 26, Dec. 26, 1929, pp. 1033–1035, 7 figs. Methods employed in manufacturing Textolite gears are described; gears fabricated out of non-metallic materials present problems somewhat different from ordinary practice; blanks may be molded for plain pinions or may be die formed with or without molded-in steel hubs and webbed wheels; tables show allowable horsepowers for Textolite gears.

GRINDING MACHINES

Rotary. New Large Rotary Grinder. Iron Age, vol. 124, no. 24, Dec. 12, 1929, pp. 1603–1604, 2 figs. Description of 108-in. rotary grinder for grinding outside and inside cylinders and cones, as well as flat surfaces, which has been built by G. A. Gray Co., Cincinnati, for Chicago Heights, Ill., plant of American Manganese Steel Co.; work table driven by 5-hp. variable-speed totally-inclosed motor; right-angle attachment permits grinding flat surfaces; 16 traverse feeds and 12 infeeds.

Twist-Drill-Web. A New Twist-Drill Web Grinding Machine, H. Rohde. Eng. Progress (Berlin), vol. 10, no. 12, Dec. 1929, pp. 315–316, 3 figs. Machine, built by R. Stock and Co., A.G., Berlin-Marienfelde; permits grinding drills of included angle varying between 110 and 140 deg.; regular equipment includes two sets of spring jaws, one set being for drills between 10 and 25 mm., or 3/8 to 1 in., while other takes sizes from 26 to 75 mm., or 1 to 3 in.; two grinding wheels are furnished with machine.

H

HANGARS

Doors, Electric Drive for. Designing Drive and Control for 600-Ton Hangar Doors, W. J. Watson. Machine Design, vol. 1, no. 3, Nov. 1929, pp. 9–12, 7 figs. Description of door-moving mechanism designed for airship hangar of Goodyear Zeppelin Corp., at Akron, Ohio. Each wheel has individual axle; worm gear also prevents swinging; electric cutout switches mounted on runway adjacent to driving unit so that projections for door operate them, door coming to slow down, increasing speed.

HEADING MACHINES

Cold-Heading Rivets. An Accurate Cold

Heading Machine. Engineer (Lond.), vol. 148, no. 3856, Dec. 6, 1929, pp. 616–617, 6 figs. Details of machine brought out by E. White, of Windsor Works, Redditch, for making such objects as rivets, screw blanks, etc. with exceptional degree of accuracy; it will, in fact, work to nearest 0.002 in.

HEAT EXCHANGERS

Characteristic Curves. Heat-Exchanger Characteristic Curves (Eschangeurs de chaleur semblables courbes caracteristiques), M. Véron. Chaleur et Industrie (Paris), vol. 10, nos. 114 and 115, Oct. and Nov. 1929, pp. 469–478, and 549–556, 5 figs. Mathematical analysis of heat exchange between fluids through separating partition; equations for thermal efficiency developed; formulas and characteristic curves giving efficiency and losses in reheaters.

Heat Transmission in. Heat Transmission in Cross-Current Heat Exchangers (Der Waermeuebergang im Kreuzstromwaermeastauscher), G. Zimmermann. Zeit. Bayerischen Revisions-Vereins (Munich), vol. 33, nos. 21, 22, and 24, Nov. 15 and 30, and Dec. 31, 1929, pp. 297–302, 315–317, and 343–350, 24 figs. Nov. 15: Temperature measurement of air and flue gases; preliminary tests; dimensioning of ducts. Nov. 30: Conducting and evaluation of tests; calculation of heat volume discharged from flue gases and heat absorbed from air. Dec. 31: Determination of temperatures of plates; heat-transfer coefficient; comparison of theoretical discharge-temperature curve with practical results.

HEAT PUMPS

Principle of. The Heat Pump—An Economical Method of Producing Low-Grade Heat from Electricity, T. G. N. Haldane. Inst. Elec. Engrs.—Advance Paper, Sept. 7, 1929, 10 pp., 7 figs. Method of converting electrical energy into heat energy is based on general principle that efficiency of heat engine working in normal cycle is given by difference between high and low temperature multiplied by high temperature; application of this principle to heating of buildings and for such purposes as heating of public baths is discussed, and estimated figures for installation are given; experiments by author demonstrated soundness of principles on which pump is based.

HOT-AIR HEATING

Fans. Friction Losses and Observed Static Pressures in a Domestic Fan Furnace Heating System, A. C. Willard and A. P. Kratz. Heating, Piping, and Air Conditioning, vol. 1, no. 8, Dec. 1929, pp. 683–687, 6 figs. With increasing tendency to apply various types of small disk and propeller fans as well as small centrifugal fans to warm-air furnace-heating system of gravity circulating types has developed without proper attention to heads or resistances; description of apparatus, test procedure, and discussion of results are given. To be presented before Am. Soc. Heat. and Vent. Engrs.

HOT-WATER HEATING

Pumping vs. Gravity Systems. Pumping vs. Gravity Heating Systems (Schwerkraft oder Pumpenheizung), M. Hottinger. Gesundheits-Ingenieur (Munich), vol. 52, no. 38, Sept. 21, 1929, pp. 657–660, 1 fig. Advantages of pumping over gravity heating systems; limiting cases; determination of pump capacity; safety provisions; comparative cost data.

HYDRAULIC MACHINERY

Design. Calculation and Design of Hydraulic Machines and Presses (Calcul et construction des presses et machines hydrauliques), A. Lambrette. Technique Moderne (Paris), vol. 21, nos. 18 and 20, Sept. 15 and Oct. 15, 1929, pp. 572–576 and 646–652, 13 figs. Practical design data and tables; description of different types of presses; choice of construction materials; installation of presses.

HYDRAULIC TURBINES

Draft Tubes. Contribution to the Theory of the Vertical and Cylindrical Draft Tubes (Bidrag till den vertikala och cirkulara sugtrummans teori), H. Berglund. Teknisk Tidskrift (Stockholm), vol. 59, nos. 42 and 46, Oct. 19 and Nov. 16, 1929 (Mekanik), pp. 132–140 and 151–152, 4 figs. Through gradual widening of suction line from turbine, author contends that higher efficiency may be reached; he develops formulas for construction of suction lines based on this theory and applies them to examples.

Propeller-Type. Hydraulic Turbines of the Propeller Type (Le turbine idrauliche ad elica), G. Buchi. Energia Elettrica (Milan), vol. 6, no. 10, Oct. 1929, pp. 1002–1023, 48 figs. Compilation on developments of design, construction and operation of Kaplan turbines and their appurtenances; description of propeller turbine installations of Lilla Edet plant in Sweden and of Mori plant in Italy; development of propeller turbines in America with special reference to Moody turbine; high- and low-speed types of Bell propeller turbine.

Regulation. Present Tendencies in Regulation of Hydraulic Turbines (Tendances actuelles en matière de regulation des turbines hydrauliques), L. Barmillion. Société des Ingénieurs Civils de France—Mémoires et Compte Rendu des Travaux (Paris), vol. 82, no. 5/6, May/June, 1929, pp. 688–715, 38 figs. General review of theory and practice of hydraulic-turbine regulation, with special reference to accelerometric and tachymetric criteria and special devices used in French practice.

Testing. Measurement of Turbine Efficiency (Sur une nouvelle méthode de mésure du rendement des turbines hydrauliques), L. Barbillion. Chaleur et Industrie (Paris), vol. 10, no. 113, Sept. 1929, pp. 423–427, 1 fig. Study of new means of measuring turbine efficiency, termed by author "thermometrical method," based on difference in temperature between water before and after passing turbines, this difference being proportional to losses of energy by friction, leakage, etc.; principles of method are disclosed with calculations worked out.

HYDROELECTRIC POWER PLANTS

Gate Control. Automatic Gate Control Maintains Normal River Flow, D. P. Dinapoli. Elec. World, vol. 94, no. 25, Dec. 21, 1929, pp. 1220, 1 fig. On Pit River development of Pacific Gas and Electric Co., gate operation must fulfil two requirements; first, to maintain given river flow and second, to vary flow to follow slight seasonal variations which accompany normal river flow; device for this purpose consists of three main elements, float mechanism, relays, and sluice gate with its motor and contactor; wiring diagram of automatic sluice-gate control equipment is given.

Pumped Storage. Two 8100 Hp. Pumps Supply Water for Power Generation. Power, vol. 70, no. 25, Dec. 24, 1929, pp. 1006–1008, 7 figs. Illustrated description of vertical-shaft, single-inlet, single-stage, bottom-suction, volute-type pumps rated at 162,000,000 gal. per day, against 240-ft. gross head used in Rodky River hydroelectric plant of Connecticut Light and Power Co.; cross-section of one of two pumps; curves obtained from test made on model pump, and on pump in actual operation.

I

INDUSTRIAL MANAGEMENT

Budget Control. Budget Control at Timken-Detroit Axle Company Pares Cost, J. Geschelin. Automotive Industries, vol. 61, no. 24, Dec. 14, 1929, pp. 860–863. Details of budget-control system of Timken-Detroit Axle Company which presents true picture of every item of expense in every corner of plant; ratio of productive labor to sales is kept constant, while considerable savings are made, by means of clear cut system; forms used are shown.

Budgeting Upkeep Keeps Down Expenses, B. A. Franklin. Indus. Eng., vol. 87, no. 12, Dec. 1929, pp. 622–623. Problem of budget for upkeep, forecasting expense of repairs and cost of plant development and improvement; discussion of methods of handling budget as employed by Strathmore Paper Co., Mittineague, Mass.

Cost Accounting. Management and Cost Accountancy, G. W. Tripp. Engineer (Lond.), vol. 148, no. 3858, Dec. 20, 1929, pp. 654–655. Cost accountant is servant of management, his functions being to present facts in manner that is required of him; having determined into which category each item of overhead cost is intended to fall, he has to ensure correct collection of these charges, so that production will pay for all services rendered.

The Executive Interest in Costs, T. B. Frank. Am. Mach., vol. 72, no. 2, Jan. 9, 1930, pp. 50–51. Cost information and facts, when properly prepared and presented, are invaluable tools for executive; chief executive of any business must have them; nature and use of some of those tools and actual needs therefore should be carefully considered.

Depreciation. Depreciation with Special Reference to the Differences in the Points of View of Accountants and Appraisers, F. M. Breslin. Soc. Indus. Engrs.—Bul., vol. 11, no. 11, Nov. 1929, pp. 9 and 13. Proper accounting for depreciation; methods in practice for distributing depreciation.

Distribution. How the Industrial Engineer Can Tackle the Distribution Problem, S. P. Farwell. Soc. of Indus. Engrs.—Bul., vol. 11, no. 11, Nov. 1929, pp. 5–6. Opportunities for industrial engineers in analyzing distribution problem.

Labor Turnover. The Art of Hiring Men, K. Rankin. Am. Mach., vol. 71, no. 26, Dec. 26, 1929, p. 1049. Since labor element in almost any product is at least equal in importance to physical material, hiring of right men to do that labor requires genuine intelligence; first step toward reducing labor turnover is to know its percentage, its cause and how it can be reduced; in this day of machine innovation and improvement employers are all too prone to minimize unduly prime importance of men.

Motion Study. Systematic Determination of Time Element in Manual Labor (Planmaessige Ermittlung der Handarbeitszeiten), F. Ludwig and E. Rauscher. Maschinenbau (Berlin), vol. 8, no. 20, Oct. 17, 1929, pp. 673–677, 22 figs. Experiments in Elmo plant of Siemens-Schuckert works; graphical tabulation of bodily strain in all possible positions; principal types of manual motions involved in wood and metal working, and in household; development of generally applicable analysis for nailing operation and practical application with example.

Production Control Measurement. Measuring Tools in Mass Production (Messwerkzeuge in der Mengenfertigung), W. Leyensetter. Maschinenbau (Berlin), vol. 8, no. 20, Oct. 17, 1929, pp. 678–682, 13 figs. Brief notes on fundamental requirements of measuring systems in quantity production; methods for measuring work pieces during work on grinding machine; some combined measuring devices are described.

INDUSTRIAL PLANTS

Air Conditioning. Control of Humidity and Temperature, W. H. Carrier. Heat. and Vent., vol. 26, no. 12, Dec. 1929, pp. 86–87, 1 fig. Various relationships, based upon principles of total heat, relation of dewpoint to relative humidity and determination of moisture content form wet- and dry-bulb temperature readings; laws and experimental data involving rate of evaporation of water in contact with air; author emphasizes importance of human element in determining requirements of air conditioning in many types of equipment. Paper presented before World Eng. Congress at Tokyo.

The Control of Humidity and Temperature as Applied to Manufacturing Processes and Human Comfort, W. H. Carrier. Heating, Piping, and Air Conditioning, vol. 1, no. 7, Nov. 1929, pp. 535–543 and 605–616, 23 figs. Discussion of theoretical and practical application of air conditioning for industrial purposes and assurance of human comfort especially in factories and auditoriums; important experimental data with reference to effective temperatures and relation to human comfort; various types of equipment used for modern air conditioning are described; systems of air distribution and importance of engineering in this field are emphasized.

INDUSTRIAL TRUCKS

Electric. Materials Handling Problems Solved by Use of Electric Truck, H. E. Stocker. Iron Trade Rev., vol. 85, no. 24, Dec. 12, 1929, pp. 1502–1503, 3 figs. Description of new electric industrial truck used in plant of Driver-Harris Co., Harrison, N. J., in manufacture of nickel-chrome wire; time and costs are cut by use of electric lift truck and platforms in moving product through various operations; four-wheel drive and four-wheel steering, sensibility and flexibility of controls, and ability to operate equally well in either direction obtained.

INTERNAL-COMBUSTION ENGINES

Compression Limits. Limit of Compression in Internal-Combustion Engines (Sur la limite de compression dans les moteurs à explosion). P. Dumanois. Bul. Technique du Bureau Veritas (Paris), vol. 11, no. 10, Oct. 1929, pp. 215–220, 1 fig. Importance of even very slight variations in time on combustion process is pointed out; investigation of what takes place when compression in engine is increased; tests were carried on to confirm, if possible, assumption that oxidation takes place during compression.

Crankshafts. Critical Speeds of Crankshafts, A. Gorfinkel. Engineering (Lond.), vol. 128, no. 3337, Dec. 27, 1929, pp. 827–829, 3 figs. Author explains how calculation may be simplified and results, sufficiently exact for practical requirements, attained with reasonable ease and rapidity; methods described originated in connection with design of Diesel engines constructed by Carels Brothers in Ghent but are applicable to all multi-throw crankshafts.

Indicators. New Compression Indicator, G. L. Holzapfel. Instruments, vol. 2, no. 11, Nov. 1929, pp. 418–419. Holzapek indicator designed to fill need for accurate and reliable instrument; is screwed into spark-plug orifice and engine cranked; owing to action of check valve, pressure

of gas pumped into space communicating with pressure gage soon reaches maximum pressure reached in engine cylinder during compression stroke, this being registered on pressure gage; check valve is so designed that it is absolutely gas-tight so that compressed gas trapped in upper part of body is held there, recording maximum compression pressure.

Thermodynamics of. The Thermodynamics of Heat Transference, A. A. Herzfeld. Automobile Engr. (Lond.), vol. 19, no. 261, Nov. 1929, pp. 441–444, 3 figs. Propagation of combustion in direction of flow of gas is given with accuracy sufficient for practical purposes; calculation of linear rates of combustion at right angles and opposite to direction of flow of gas; formulas for L-head engine; method for determining volumetric efficiency of existing engine; determining heat developed by each combustion; by these formulas, places of highest heat transference can be determined.

Vibration. The Effect of the Damping of the Throws on the Torsional Vibration of the Crankshaft system of an Internal Combustion Engine, J. Morris. Roy. Aeronautical Soc. (Lond.), vol. 33, no. 227, Nov. 1929, pp. 1086–1087, 2 figs. Formulas for frequencies in torsional vibrations of crankshaft of direct-drive engine having equal throws and equal journals; in view of considerable moment of inertia of airscrew compared with that of throw, author finds that its damping will not appreciably affect above result, which again is exact having regard to conditions assumed.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; OIL ENGINES.]

J

JIGS AND FIXTURES

Design. The Planning and Design of Stand Type Jigs, J. A. Potter. Am. Mach., vol. 72, no. 2, Jan. 9, 1930, pp. 62–63, 4 figs. Standards of quality and tolerance, as well as available machines, dictate type of fixture and number of operations; exposition of various factors governing type of jig to be used on particular production job.

L

LATHES

Cutting Tools. Cutting Capabilities of Lathe Tools, D. Smith. North-East Coast Instn. of Engrs. and Shipbldrs.—Advance Paper (Newcastle-upon-Tyne), Dec. 6, 1929, 26 pp., 13 figs. Brief outline of development of cutting metals, their chemical composition and functions; Stellite, Cooperite, Widia, and Perdurum; heat treatment of tool steels and some of their properties; difficulty experienced in obtaining rational law between cuts of different dimensions and cutting speed; work done by Manchester Lathe Tool Committee on effect of depth of cut and traverse, shape of tool, and speed on durability of ordinary high-speed tools; also on forces exerted on tool when cutting iron and steel.

LIGHTING

Industrial. Cost of Lighting Industrial Buildings, M. Luckiesh. Elec. World, vol. 94, no. 24, Dec. 14, 1929, p. 1181. In recent analysis cost of lighting six representative types of industrial buildings, four single-story, and two multi-story, for eight-hour work period in daytime and for average weather conditions, was studied.

LOCOMOTIVES

Diesel. Cummins Diesel for Locomotive Is Given Test Run. Automotive Industries, vol. 61, no. 25, Dec. 21, 1929, pp. 911–912, 2 figs. Description of six-cylinder solid-injection Diesel engine for railroad locomotive works; which has been built by Cummins Engine Co., Columbus, Ind.; bore and stroke of 10 and 12 in., respectively; 500 hp. developed at 800 r.p.m.; governor is fitted and speed can be varied from idling 350 r.p.m. to maximum; results of tests made for Pennsylvania Railroad Co.

1200-H.P. Diesel-Compressed-Air Locomotive for the German State Railways. Engineering (Lond.), vol. 128, no. 3334, Dec. 6, 1929, pp. 748–749, 1 fig. Mechanical portion was built by Maschinenfabrik Esslingen A.-G. of Esslingen, while Diesel engine and compressed-air transmission, with which it is equipped, were manufactured by Maschinenfabrik-Augsburg-Nurnberg (M.A.N.); locomotive is of 4–6–4 type; power developed by engine is utilized for drying air compressor; compressed air thus obtained is passed into heater, through which exhaust gases from engine are led, and is then transmitted to locomotive cylinders, which are placed outside frames at one end.

Electric. 5400-H.P. Electric Locomotive for the Paris, Lyons, and Mediterranean Railway. Engineering (Lond.), vol. 128, no. 3335, Dec. 13, 1929, pp. 786–787, 2 figs. Details of locomotive made by Oerlikon designed so as to be capable of hauling 700-ton train at speed of 56 m.p.h. up gradient of 0.8 per cent, and at 68 m.p.h. on level; consists essentially of single frame, which is mounted on two articulated subframes; each of latter is equipped with three driving axles and truck, latter being of standard P.L.M. type; two pantograph collectors and four contact shoes on each side are provided for current-collection purposes.

Feedwater Heaters. Locomotive Feed Water Heater. Engineer (Lond.), vol. 148, no. 3857, Dec. 13, 1929, p. 632, 3 figs. Improved type of A.C.F.I. apparatus has been fitted to Pacific type engines No. 2580, Shotover and No. 2576 White Knight, on L. and N. E. Railway; standard type of A.C.F.I. heaters consisting of two circular chambers placed on top of boiler behind chimney, have been superseded by heater arranged to fit into smokebox ahead of chimney; this arrangement eliminates heat losses by radiation.

Fireboxes, Copper Welding. Copper Welding (Die Kupferschweissung), R. Samesreuther. V.D.I. Zeit. (Berlin), vol. 73, Dec. 7, 1929, pp. 1731–1732, 4 figs. Discussion deals principally with copper welding of locomotive fireboxes; comparison of riveted and welded copper fireboxes; method of welding and after-treatment of welds.

Forgings. Locomotive Forgings, L. H. Fry. Am. Soc. Steel Treating—Trans., vol. 17, no. 1, Jan. 1930, pp. 1–33 and (discussion) 33–53, 17 figs. Production of locomotive forgings which will give good results in service necessitates employment of correct methods from melting of steel to finished forging; various steel-melting processes are discussed and compared; importance of ingot structure is considered; forging process is described and resulting structures of steel forgings illustrated by photomicrographs.

Freight. Great Northern Adds to 2–8–8–2 Type Motive Power. Ry. Age, vol. 87, no. 26, Dec. 28, 1929, pp. 1477–1478, 1 fig. Description of freight locomotives, built at Hillyard, Wash.; exceptional tender capacity provided; cylinders 28 by 32 in.; driving wheels 64 in.; boiler pressure 210 lb. per sq. in.; maximum tractive force 146,000 lb.; total engine weight in working order 630,750 lb.; total engine wheelbase 70 ft.–7¼ in.

High-Pressure. High-Pressure 4–6–2–2 Type Locomotive on the London and North Eastern Railways. Engineering (Lond.), vol. 128, no. 3337, Dec. 27, 1929, pp. 850, 8 figs.; see also Ry. Gaz. (Lond.), vol. 51, no. 25, Dec. 20, 1929, pp. 973–976, 5 figs.; and Modern Transport (Lond.), vol. 22, no. 562, Dec. 21, 1929, p. 15, 5 figs. Engine just completed on the London and North Eastern Railway to designs of H. N. Gresley is for express passenger work, has four compound cylinders and boiler pressure is 450 lb. per sq. in.; cylinders, 12 by 20 by 26 in.; weight of engine, in working order, 103.6 tons; total engine wheelbase 40 ft. 0 in.

Industrial; Operation Costs. Performance and Costs of Operating Fireless Steam Locomotive in Shuttle Service at a Steel Plant. Iron and Steel Engr., vol. 6, no. 10, Oct. 1929, pp. 554–557. Results of investigation made by Weirton Steel Co. of Fireless locomotive employed in blooming mill on shuttle work in placing buggies of load ingots beside soaking pits; steam units used but without boiler or firebox, these being replaced by lagged and jacketed tank; water in tank is heated by steam from stationary boiler plant to full boiler temperature and pressure, and thereafter unit operates as standard locomotive until charge is exhausted; operating costs versus standard Fireless type.

LUBRICATING GREASES

Zinc Oxide. A Zinc-Containing Lubricant for the Prevention of Corrosion. Metals and Alloys, vol. 1, no. 6, Dec. 1929, pp. 281–283. In running of device known as Keenok pinion in which rapidly varying local stresses are set up, it was found that serious trouble was caused by corrosion of working parts; conclusion wa reached that corrosion was electrolytic effect produced by rapidly varying local stresses to which parts were subjected; prolonged study was made of means to prevent corrosion; successful results were reached by employing as lubricant grease with which considerable proportion of zinc oxide was mixed. From Engineer (Lond.), Sept. 27, 1929.

M

MACHINERY

Obsolescence. Put Profits Into New Equipment, W. H. Rastall. Iron Age, vol. 125, no. 1, Jan. 2, 1930, pp. 72 and 76. Obsolescence of machinery must be provided for by setting aside fixed percentage of profits; criticism of Japanese spinning mills accounting methods; British industries failed to set up reserves; accountants confuse depreciation and obsolescence.

Welded Construction. Economy of Material in Welded Construction, M. Hilpert. Welding Jl. (Lond.), vol. 26, no. 313, Oct. 1929, pp. 315–316 and 331, 4 figs. Figures and data give probable reduction in weight secured by welding process, compared with other methods of assembly. Abstract of paper presented before Matls. Congress in Berlin.

Welding in Machinery Manufacture (Schweissen im Maschinenbau), H. Neese. V.D.I. Zeit. (Berlin), vol. 73, no. 49, Dec. 7, 1929, pp. 1738–1739, 12 figs. Advantages of welding in machinery manufacture are briefly set forth; good machines, good electrodes, and good training of welders are, however, absolutely necessary.

MAGNESIUM ALLOYS

Temperature Effect. Compression and Extrusion, A. Portevin. Metallurgist (Supp. to Engineer, Lond.), Nov. 1929, pp. 173–175, 2 figs. Review of paper previously indexed from Revue de Métallurgie, Aug. 1929; relationship between behavior of given metal or alloy under high-temperature compression test and its behavior in extrusion press is discussed; author obtains autographic stress-strain diagrams of four-distinct types; interpretation of these four types in terms of single generalized pair deformation of metal under viscous flow and under work-hardening conditions, respectively.

MALLEABLE CASTINGS

Use in Machine Construction. Malleable Castings Offer Many Possibilities to Designers, J. B. Deisher. Machine Design, vol. 1, no. 3, Nov. 1929, pp. 31–34, 4 figs. Applications of malleable castings to machine construction are discussed; machineability of malleable casting is one of its economic virtues; castings can be poured at comparatively low casting temperature resulting in smooth surface; present and potential uses; research and standardization of quality.

METAL SPRAYING

Compressed-Air. Protection of Steel from Corrosion by Non-Ferrous Metals. Metal Industry (Lond.), vol. 35, no. 22, Nov. 29, 1929, p. 518, 2 figs. Description of mechanical process of spraying molten metal directly on to steel, developed by Metals Coating Co.; wire of any commercial metal is fed at definite rate through nozzle into oxyacetylene or oxy-hydrogen flame; molten metal is atomized and sprayed by means of compressed air; special attachment used when tubes are to be coated internally.

METALS

Cold Working. Effects of Cold Working on Physical Properties of Metals, R. L. Templin. Am. Inst. Min and Met. Engrs.—Tech. Pub., no. 238, 1929, pp. 1–15 and (discussion) 15–17, 2 figs. Factors of variations in conditions present in remounting, casting, chilling, and preheating of initial ingot are assumed to remain constant; factors that must be considered simultaneously with cold working; definition of cold work and equivalent cold work; graphs, tabular data, and formulas are given. Bibliography.

Hard-Facing. Development and Application of Hard-Facing, M. C. Smith. Machy. (N. Y.), vol. 36, no. 3, Nov. 1929, pp. 219–222, 6 figs. Description of materials and methods employed in newly developed process of applying veneer of hard alloy to metal surface by fusion welding; repairing oil-well tools by welding on metal lead to development of hard-facing; three classes of alloys used in hard-facing; problem of finding suitable hard-facing alloy; theory of mixed-alloy welding rod; substituting hard-facing for heat-treatment; kinds of hard-facing alloys available; advantages offered by hard-facing process.

Testing. Vibration Strength (Schwingungsfestikeit), P. Ludwik. Zeit. des Oesterreichischen Ingenieur und Architekten Vereines (Vienna), vol. 81, nos. 41/42, Oct. 11, 1929, pp. 403–406. Results of bending and impact endurance tests of polished and variously notched bars of duralumin,

copper, zinc, cast iron, steel, steel alloys, and other metals, are discussed.

MORTISING MACHINES

Tests. Mortising Wood (Langlochfraesen in Holz), G. Harnisch. V.D.I. Zeit. (Berlin), vol. 73, no. 43, Oct. 26, 1929, pp. 1538–1540, 13 figs. Communication regarding tests made by author on design and performance of usual mortising and characteristics of various kinds of woods.

MOTOR TRUCKS

Design. Trends in Motor Truck Design, B. B. Bachmann. Ry. Age (Motor Transport Sec.), vol. 87, no. 26, Dec. 28, 1929, pp. 1513–1514. Discussion of general characteristics of motor-truck design showing that modern design is balanced between transportation requirements of vehicle and available materials of construction.

Differentials. Differential Drives of French Motor Trucks (Wechselgetriebe franzoesischer Kraftwagen), A. Heller. V.D.I. Zeit. (Berlin), vol. 73, no. 44, Nov. 2, 1929, pp. 1586–1587, 4 figs. Means for improving driving characteristics with special regard to acceleration in starting; four-gear drives with noiseless third speed; transmission gears for three-speed drives.

N

NON-FERROUS FOUNDRY PRACTICE

Castings. Notes on Castings, L. Shane. Am. Soc. Naval Engrs.—Jl., vol. 41, no. 4, Nov. 1929, pp. 589–596. Author claims that difficulty in making composition G castings is almost exactly contemporaneous with introduction of open-flame furnace, such as Schwartz, or Rockwell, or Monarch furnaces; writer has solved problem in many places, reducing losses to almost negligible extent by merely requiring manufacturing plants where he has been on duty to return to practices of 35 years ago; procedure in effect at Portsmouth Navy Yard where difficulties in manufacture of Composition G have been overcome; method of manufacture of manganese bronze; monel castings.

High-Melting-Point Alloys. The Foundling of Some High Melting Point Alloys, J. McNeil. Metal Industry (Lond.), vol. 35, nos. 21 and 22, Nov. 22 and 29, 1929, pp. 489–492 and 522–523, 3 figs. Nov. 22: Production of castings in Admiralty gunmetal, and differences in founding technique of high-melting-point alloys; similar features in nickel-silver, nickel-copper, and nickel-chromium alloys; furnaces; crucibles; melting procedure; fluxes; effects of oxygen, carbon, sulphur, and magnesium. Nov. 29: Requirements for melting and superheating monel metal; nickel-chromium alloys; remelting; molding; cores and facings. Read before Inst. of Brit. Foundrymen.

O

OIL ENGINES

Indicators. Indicating Oil Engines, G. B. Fox. Diesel Engine Users Assn. (Lond.), no. 307, 1929, pp. 1–15 and (discussion) 16–30, 9 figs. Discussion of manipulation of indicator, defects; indicating air compressors; light spring diagrams; tuning multi-cylinder engine; reference to examples; types of diagrams; types of indicators; simple dead-weight spring tester.

P

PLANERS

Hydraulic-Drive. Planing Machine With Hydraulic Drive (Tischhobelmaschine Mit Fluessigkeitsantrieb), M. Kronenberg. Werkstattstechnik (Berlin), vol. 23, no. 21, Nov. 1, 1929, pp. 613–615, 1 fig. It is shown that from theoretical point of view, machines which avoid all rotary masses must be efficient and would make possible development of planers into speed-cutting equipment; design of machine of this type is discussed; tests have shown increase in cutting power, quiet performance, and smooth reversing.

PRESSURE VESSELS

Design. Building of Vessels for High Pressure and High Temperature Service, T. M. Jasper. Combustion, vol. 1, no. 6, Dec. 1929, pp. 23–30, 13 figs. Paper considers pressure vessels intended for severe service under following headings: design, materials, fabrication, and testing; proper method of design is to construct pressure vessel and then test; results of various tests are shown graphically; discussion of various materials for pressure vessel construction together with their outlet strengths; methods of plate manufacture; welded joint testing. Paper read before Tokyo World Engineering Congress.

PROTECTIVE COATINGS

Metallic. Practical Experiences With Protection of Boiler Parts Against Combustion by the "Alumetier" Process (Praktische Erfahrungen ueber den Schutz von Kesselteilen gegen Verbrennung durch das Alumetierverfahren), C. Commentz. Korrosion und Metallschutz (Leipzig), vol. 5, no. 11, Nov. 1929, pp. 248–249. "Alumetier" process, which has been successfully used in past few years for protection of grate bars and other boiler parts from furnace gases, consists in first spraying metal parts with aluminum layer, after which they are given airtight coating; aluminum and iron are diffused at suitable temperature, thus forming tanaceous heat-resisting alloy.

PUMPS

Oil. The Hele-Shaw Beacham Oil Pump. Engineering (Lond.), vol. 128, no. 3334, Dec. 6, 1929, pp. 739–740, 5 figs. By slight alteration and simplification same mechanism as employed on firm's air motor, previously described, has been converted into highly effective oil pump for circulating oil in transformers.

PUNCH PRESSES

Clutch for. Automatic Safety Clutch for Punch Press, R. Tilkin. Machy. (N. Y.), vol. 36, no. 4, Dec. 1929, pp. 273–274. Details of safety clutch used on punch presses operated by eccentric shafts which stop after each revolution at exactly same position, so that ram is returned to its original starting point.

PYROMETERS

Recording. A New Potentiometer Pyrometer Recorder. Metals and Alloys, vol. 1, no. 6, Dec. 1929, p. 276, 2 figs. New potentiometer recording pyrometer developed by Wilson-Maeulen Co., N. Y., which has temperature record chart 12 in. wide, and shows number of other new features of mechanical and electrical design.

R

RAIL MOTOR CARS

Gasoline-Electric. Separate Power Supply for Rail Car Auxiliaries. Ry. Elec. Engr., vol. 20, no. 12, Dec. 1929, pp. 414–417, 4 figs. Description of two new power plants, one six-cylinder and other eight-in-line, of similar design, developing 400 and 535 hp., respectively, developed by J. G. Brill Co., Philadelphia; eight-cylinder equipment described in detail; in addition to main engine, small automotive-type four-cylinder of 15 hp. is used to drive 32- to 40-volt generator, having continuous rating of 7.5 kw., for battery charging and other purposes; low-voltage circuit diagram given.

Results With. Rail Motor Car Section. Ry. Age, vol. 87, no. 21, Nov. 23, 1929, pp. 1234–1235, 1 fig. Review of Rail Motor Car Section of Toronto Meeting of Motor Transport Division, American Railway Assn., with abstracts of reports and papers; Comparison of Ability of Rail Motor Cars Versus Steam for Operation Under Serious Snow Conditions, Lollis; rail cars attract no traffic; rail car in Canada; description of rail motor train, Blue Bird, operated daily by Chicago Great Western between Rochester and Minneapolis.

ROLLING MILLS

Bearings. Report of the A.I. and S.E.E. Special Committee on Bearings and Special Study Regarding Lubrication of Anti-Friction Bearings on Mill and Crane Motors, F. D. Egan. Iron and Steel Engr., vol. 6, no. 10, Oct. 1929 (discussion), pp. 547–551. Discussion of paper published in July 1929 issue of magazine, which was given by A. J. Standing, J. L. Brown, C. C. Pecue, H. A. Winne, A. M. MacCutcheon, S. N. Roberts, and W. B. Connally.

Roll Bearings for Cold Rolling Mills, C. E. Davies. Metal Industry (Lond.), vol. 35, nos. 20 and 21, Nov. 15 and 22, 1929, pp. 459–462 and 496–497, 5 figs. Nov. 15: Conditions under which cold roll bearings are called upon to operate; British practice in cold rolling steel and non-ferrous metals; unavoidable disadvantages of roller bearings; demand for highly efficient and robust bearings; forced lubrication; design of bearings for flood lubrication; recirculating oil. Nov. 22: Trouble due to heating of bearings eliminated; exceptionally lower power consumption at highest speeds attained, taking maximum possible reduction per pass; high-speed strip mill.

Experimental. Cold-Rolling Mill at the Research Laboratory, Sheffield University. Engineering (Lond.), vol. 128, no. 3334, Dec. 6, 1929, pp. 729–730, 5 figs. partly on p. 728. New laboratory to be devoted to study of cold working of metal is equipped with plant equal, if not superior in capacity and efficiency, to any similar installation of experimental machinery for research work in connection with cold rolling and drawing of metals; rolls, which are 10 in. in diam. by 10 in. face, are suitable for cold rolling steel and any other metal strip up to 6 or 7 in. wide, and any thickness from $^{3}/_{16}$ in. down to thinnest strip usually rolled; these rolls are of Hadura alloy steel.

S

SHAFTS AND SHAFTING

Bearings for. Bearings for Line-Shafting, G. F. Charnock. Engineering (Lond.), vol. 128, nos. 3336 and 3337, Dec. 20 and 27, 1929, pp. 801–802 and 836–837 and (discussion) 811–812, 12 figs.; see also Engineer, vol. 148, nos. 3858 and 3859, Dec. 20 and 27, 1929, pp. 670–672 and 694–696, 26 figs. and (discussion) pp. 666–667. Dec. 20: Theory of film lubrication. Dec. 27: Results of tests carried out by author to ascertain efficiency of various types of lineshaft bearings under varying loads and at different speeds. Paper read before Instn. Mech. Engrs., Dec. 13, 1929.

Out-of-Balance Drive. Applications of the Out-of-Balance Drive. Engineering (Lond.), vol. 128, no. 3337, Dec. 27, 1929, pp. 852–853. Two applications of vibration when shafting is out of balance are illustrated, one on power-operated road tamper, and other in sifting screen.

SHEET-METAL WORKING

Drawing. Influence of Rounding Off in Drawing of Hollow Pieces of Thin Sheet (Einfluss der Abrundung beim Ziehen von Hohlkoerpern aus duennen Blechen), H. Draeger. Stahl und Eisen (Duesseldorf), vol. 49, no. 48, Nov. 28, 1929, pp. 1731–1732. Results of author's experimental investigations; influence of rounding off of drawing angle on tensile stress of workpiece was tested on brass and white-metal sheets.

STEAM

High-Pressure. High-Pressure Steam Operation in Future Economic Practice (Der Hochdruckdampfbetrieb in der zukuenftigen Engergiewirtschaft), S. Loeffler. Ingenieur (Hague), vol. 44, no. 45, Nov. 9, 1929, pp. 223–231, and (discussion) W231–232, 16 figs. High-pressure steam processes and equipment are discussed from standpoint of opinion, still prevailing sometimes, that there is no advantage in applying pressures over 35 atmos.; author states that no advantage is to be obtained when temperature is not raised accordingly; high-pressure boilers, equipment, pipe lines, and operation characteristics are given.

STEAM CONDENSERS

Water Chlorination. Chlorinating Circulating Water Keeps Condenser Clean, V. M. Frost and W. F. Rippe. Power, vol. 70, no. 25 Dec. 17, 1929, pp. 961–963, 6 figs. Investigation at Kearny station for purposes of experimenting with chlorine gas for treatment of circulating water; discussion of test procedure; chart showing record of chlorination dosage and concentration; curve of heat-transfer comparison of chlorinated and unchlorinated condenser; list of pro and con items of chlorination. Abstract of paper read before Metropolitan Section, A.S.M.E., Nov. 21.

STEAM-ELECTRIC POWER PLANTS

Birmingham, England. The Hams Hall Generating Station of the Birmingham Corporation. Engineering (Lond.), vol. 128, nos. 3336 and 3337, Dec. 20 and 27, 1929, pp. 793–796 and 829–832, 34 figs. partly on supp. plates. Dec. 20: Particulars of main turbo-alternators with maximum continuous rating of 30,000 kw. and running at speed of 1500 r.p.m.; turbines are of single-casing type, impulse blading being used throughout. Dec. 27: Switchgear and main transformers.

France. Extensions in the Issy-Les-Moulineaux Plant of the Companie Parissienne de Distribution d'Electricité (Les Extensions de

l'Usine d'Issy-Les-Moulineaux de la Compagnie Parisienne de Distribution d'Electricité), Galatoire-Malégarie. Génie Civil (Paris), vol. 95, no. 14, Oct. 5, 1929, pp. 314–323, 13 figs., partly on supp. plates. Extension comprises six boilers of 1800 sq. m. and 44 kg. steam pressure superheated to 450 deg.; turbo generator of Companie Electro-Mécanique of 35,000 kw. and two of 11,000 kw. of Société Generale de Construction Electriques et Mecaniques and Société Rateau; notes on boiler and turbine equipment, coal and ash handling, etc., and construction of building; double-page plate of drawing.

New York City. 160,000-KW. Generator Goes Into Operation at the New York Edison Company's Plant, D. S. Snell. Power, vol. 70, no. 27, Dec. 31, 1929, pp. 1030–1033, 7 figs. Discussion of mechanical features of unity power factor, three-phase, 25-cycle, 1500-r.p.m., 11,400-volt generator recently installed in 14th St. station of New York Edison Co.; procedure in shipment and handling; unusual arrangement of ventilating air-cooling system; outline of ventilating system, showing arrangement of blowers, air coolers, and housings; electrical features. See also Engineering Index, 1928, p. 1744.

Operating Pressures and Temperatures. Steam Pressure and Temperatures, F. S. Clark. Power, vol. 70, no. 24, Dec. 10, 1929, pp. 932–935, 6 figs. Conclusions of study made by author and associates of Stone and Webster; effect of various factors that should be considered in selecting operating pressure and temperature of central power plant; experience with 1200-lb. installations; fuel economy of high steam pressures and temperatures; growth in capacity of turbine-generator units since 1903; developments in higher steam temperatures; moisture in turbine exhaust for various initial steam conditions. Abstract of paper presented at World Power Conference in Tokyo.

STEAM POWER PLANTS

Design. Influence of Operating Conditions on Layout and Cost of Construction of Steam Power Plants (Einfluss der Betriebsverhaeltnisse aud die Ausgastaltung und die Ausbaukosten von Dampfkraftanlagen), J. Kock. Waerme (Berlin), vol. 52, no. 50, Dec. 14, 1929, pp. 955–960, 10 figs. Importance of obtaining reliable basic data for design of a plant; factors governing selection of power equipment and pipe lines; advantages in use of constant-pressure accumulators combined with regenerative process; peak-load service; examples are given showing advantages of constant-pressure accumulators.

High-Pressure. The Future of Higher Steam Pressures in Steam Electric Generating Stations, I. E. Moultrop. Am. Inst. Elec. Engrs.—Jl., vol. 48, no. 12, Dec. 1929, pp. 875–877. See also Power, vol. 70, no. 27, Dec. 31, 1929, pp. 1035–1036. Construction and operating experience has shown that large part of theoretically possible gains in efficiency due to higher steam pressures has been obtained in practice; future possibilities of higher pressures are described.

STEAM PIPE LINES

Design. Models Make for Accessibility in Delray Piping, F. Thorp and R. M. Van Duzer, Jr. Power, vol. 70, no. 25, Dec. 17, 1929, pp. 956–960, 5 figs. General description of Delray Power House No. 3, of Detroit Edison Co. illustrated description of piping arrangement model to facilitate design; cross-section of plant, showing spaces reserved for piping; isometric diagram of main and auxiliary super-head steam piping, showing doubleheader system; illustration showing typical grouping of boiler-feed control valves arranged at end of bunker; piping standards and valve selections.

Water Separators. Calculation of Water Separators for Steam Pipe Lines (Berechnung der Wasserabscheider fuer Dampfleitungen), E. Kaschny. Waerme (Berlin), vol. 52, no. 44, Nov. 2, 1929, pp. 824–929, 3 figs. Table is given which can be used to determine diameter of water separator; points to be observed in calculation of wall thickness; use of welded separator for high pressures and temperatures should be avoided.

STEAM TABLES

Callendar. The Critical Region in Steam (Das kritische Gebiet des Wasserdampfes) E. J. M. Honigmann. Zeit. des Oesterreichischen Ingenieur und Architekten Vereines (Vienna), vol. 81, nos. 37/38 and 39/40, Sept. 13 and 27, 1929, pp. 371–374 and 387–390, 8 figs. Critical discussion of Callendar's extended steam tables published in Engineering, May 3 and 10, 1929, previously indexed.

STEAM TURBINES

Design. General Trend of Steam Turbine Development, E. L. Robinson. Blast Furnace and Steel Plant, vol. 17, no. 12, Dec. 1929, pp. 1825–1829, 8 figs. Results that have been attained through improvements in steam utilization in production of power by steam turbine are outlined; fuel savings striking; size of units; double flow units; regenerative cycle; economic rating; higher temperatures; resuperheated; higher pressures; compound units; economic indications; heat rates; auxiliary apparatus. Paper presented before World Power Conference at Tokyo.

Limits of Economy, Pressure, Temperature, and Output in Turbine Design (Grenzen der Wirtschaftlichkeit, des Druckes, der Temperatur und der Leistungen im Turbinenbau). Brennstoff und Waermewirtschaft (Halle), vol. 11, no. 15, Aug. 1, 1929, pp. 266–270, 7 figs. Curves showing progress in heat consuming from 1905 and estimated up to 1935; efficient coefficients and heat consumption per kw-hr. of ideal and actual installation; 6000 kw. for 50 atmos. and 20 atmos. back pressure at 3000 r.p.m. and 1060 to 1500 hp. Diesel engine installations are discussed and compared.

STEEL

Aircraft. Steels for Automobiles and Aeroplanes, W. H. Hatfield. Automobile Engr. (Lond.), vol. 19, no. 261, Nov. 1929, pp. 464–474, 1 fig. Review of steels available for use in manufacture of automobiles and airplanes; manufacture of steel used in automobile and airplane production reviewed; ordinary carbon and alloy steels; valve steels; spring steels and springs; steels for chassis frames and bodies; tubes; nitriding steels and nitralloy; rustless steels; rustless sheets and strips; most suitable steel for each part is recommended in five-page table.

Alloy. New Fields for Alloy Steels Opened by More Exacting Demands, C. E. MacQuigg. Iron Trade Rev., vol. 85, no. 25, Dec. 19, 1929, pp. 1559–1561. Present adaptations of alloy steels and how they have solved multitude of problems where question of physical properties was paramount; in 1928 over 6 per cent of entire production of steel in this country was alloy steel, including copper-bearing steel; bridges, rails, airplanes, and cutting tools constitute four typical applications. Abstract of paper presented before Am. Inst. Min. and Met. Engrs.

Types of American Alloy Steels, E. F. Cone. Iron Age, vol. 124, no. 26, Dec. 26, 1929, pp. 1735. Results of canvass of 1928 production to determine how much alloy-steel of different types was made in United States; copper and chromium steels lead in ingots; molybdenum alloy steels; many special steels are made; features of alloy cast steels; chromium leads among alloying metals; some of industrial uses.

Electric-Process. Production of Electric Steel for Castings, G. Batty. West. Mach. World, vol. 20, no. 12, Dec. 1929, pp. 451–454, 1 fig. Two sharply differentiated methods of procedure are discussed as being applicable to production of both straight-carbon and alloy steels for castings; it is affirmed that, in ordinary conditions that pertain in steel foundry, where scrap contaminated by adherent sand is used as part of charge, definite boil of bath must be secured; with some inevitable elimination of carbon; in order that finely devided nonmetallics be cleansed from bath.

STRUCTURAL STEEL

Welding. Electrically Welded Steel Structures (Elektrisch geschweisste Eisenkonstruktionen), E. Rosenberg. V.D.I. Zeit. (Berlin), vol. 73, no. 59, Dec. 7, 1929, pp. 1742–1746, 24 figs. Preliminary tests are described for welding of steel railroad bridge, based on which basic calculations are recommended; suggestions for simplification of design with regard to advantages of electric welding; reliability of welded joints; description of electrically welded roof of 100-m. long and 12-m. wide pavilion.

T

TEMPERATURE

Control. Time-Cycle Control Units. Am. Mach., vol. 71, no. 26, Dec. 26, 1929, p. 1043, 3 figs. Photographs are given showing examples of what may be accomplished in governing of operations having repetitive timing.

High, Measurement of. The Accurate Measurement of High Temperature, W. E. Forsythe. Am. Ceramic Soc.—Jl., vol. 12, no. 12, Dec. 1929, pp. 780–813, 9 figs. Standard temperature scale defined; methods of measuring temperature from very low values to highest obtainable are described; use of thermocouples discussed; different form of optical pyrometers discussed and advantages and disadvantages of types pointed out; use of absorbing screens in extending scale of optical pyrometer outlined.

TOOL STEEL

Hardening. Inherent Hardenability Characteristics of Tool Steel, B. F. Shepherd. Am. Soc. Steel Treating—Trans., vol. 17, no. 1, Jan. 1930, pp. 90–110 and (discussion) 110, 15 figs. Paper discusses variations in hardening properties encountered in carbon tool steels; pointing out that among steels of practically identical composition, wide variations in depth of hardness penetration are possible; it shows by use of special test, magnitude of these variations between heats from same manufacturer and between different manufacturers.

V

VISCOSIMETERS

Hot-Wire. Two Hot-Wire Viscosimeters, E. G. Richardson. Jl. of Sci. Instruments (Lond.), vol. 6, no. 11, Nov. 1929, pp. 337–343, 6 figs. Instruments based on convective cooling of electrically heated wire, for giving distribution of velocity across liquid, flowing in cylindrical tube and flowing in annular space between two concentric cylinders, one rotating and other at rest; examples of their use are given.

W

WAGES

Wage-Payment Plans. Group Wage Payment Increases Efficiency, J. H. Marks. Machy. (N. Y.), vol. 36, no. 4, Dec. 1929, pp. 283–285. Discussion of wage system employed by Packard Motor Car Co., which has served as incentive to employees to increase their output; after trial of six years, system has been found to increase general efficiency 35 per cent and raise wages of employees 15 per cent; employees work not only fast, but carefully; imcompetent or unambitious workmen are automatically eliminated by action of men themselves.

Task and Bonus Wage System Helpful in Power Plants, W. N. Polakov. Power, vol. 70, no. 23, Dec. 3, 1929, pp. 893–895, 3 figs. Practical discussion of objects and rewards of task in bonus wage system; bonus for power-plant personnel; sample instruction card of task.

WATER WHEELS

Pelton. Unsteady Jet Flow From Pelton Wheel Nozzles, R. H. Evans. Engineering (Lond.), vol. 28, no. 3333, Nov. 29, 1929, p. 701, 2 figs. Experiments were carried out on 7-hp. Pelton wheel, $14\frac{1}{2}$ in. diam. at Leeds University; results show that it is very desirable to fit series of guides behind needle, parallel to axis, so as to eliminate any whirl in water and reduce amount of turbulence near jet.

WELDING

Electric. See ELECTRIC WELDING.

Machinery. See MACHINERY.

Rods for. Progress in Use of High-Grade Welding Rods (Fortschritte in der Verwendung hochwertiger Schweissdraehte), F. Sommer. V.D.I. Zeit. (Berlin), vol. 73, no. 49, Dec. 7, 1929, pp. 1764–1768, 5 figs. After description of welding rods in general use, some new types are described; special mention is also made of new rods for corrosion and heat-resisting welds and wires for autogenous welding.

Structural Steel. See STRUCTURAL STEEL.

Technique of. Welding Technology (Schweisstechnik), Fuechsel. V.D.I. Zeit. (Berlin), vol. 73, no. 49, Dec. 7, 1929, pp. 1725–1726 and 9 figs. partly on supp. plate. Brief notes on applications and limitations of welding, introductory to series of article in same journal on welding practice, each of which is indexed separately.

WORLD ENGINEERING CONGRESS

Tokyo, Japan. The World Engineering Congress in Japan. Engineering (Lond.), vol. 128, nos. 3336 and 3337, Dec. 20 and 27, 1929, pp. 820–825 and 853–855. Dec. 20: Summaries covering number of miscellaneous subjects; production and use of coal; Diesel-engine problems; machine tools; agricultural engineering; electrical engineering; telegraphy, telephony, etc.; illuminating engineering; endurance properties of metals; general metallurgy. Dec. 27: Aeronautics; steam plants; turbo-compressors and pumps; hydroelectric installations.

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IN TWO SECTIONS—SECTION TWO

MECHANICAL ENGINEERING

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What It's All About

TO BE TRULY representative of such a broad field as mechanical engineering, a magazine must publish articles on a variety of subjects. Even though great care is used in selection, and even though the articles are written with a wide audience in mind, readers will receive them with different degrees of interest. In order to serve the busy reader, this supplementary section to MECHANICAL ENGINEERING is prepared to comment on the contents of the March issue. It is one way in which you can learn "what it's all about."

Airplane in Warfare

THE scene of destruction on the front cover of the March issue of MECHANICAL ENGINEERING, which shows the damage wrought by a bomb dropped from an airplane, may seem out of harmony with the program for naval disarmament which is being discussed at London and the sincere hopes for peace which are being expressed in all countries. The grim reminder of the possibilities possessed by the airplane as an offensive weapon of modern warfare as well as its use for observational purposes should serve, however, to develop a soberly reflective attitude of mind toward the military uses of a modern transportation facility.

In the March issue of MECHANICAL ENGINEERING Leon Cammen writes on "The Military Value of Aviation." Mr. Cammen points out that the defense line, which in the last war was a line of trenches extending from Switzerland to the sea, has suddenly lost importance as a means of protecting the territory back of it because warfare has now become three-dimensional rather than two-dimensional. The World War developed the use of aircraft for observation and artillery spotting near the battle line, as it did bombing and machine-gun firing, but less use was made of the airplane for observation far behind the enemy's lines and for the bombing of strategic points well removed from the scenes of actual combat.

Another effective weapon developed during the recent war, poison gas, combined with the extremely mobile and elusive airplane, brings the terrors of warfare directly to civilian populations because a land-bound defense line has been rendered less effectual. And with the development of passenger-carrying airplanes, like the Keystone "Patrician" whose interior is pictured in this supplement, troops can be transported in as large numbers as facilities permit, with possibilities which Mr. Cammen outlines in his article.

ELMER A. SPERRY—HONORED IN THIS COUNTRY AND IN JAPAN

Engineering in Japan

JAPAN'S grand old man, Viscount Shibusawa, is ninety years old. Within his lifetime Japan has added to her ancient culture the best that the machine civilization of western nations has had to offer, and has put herself on an equality with great modern powers. The development of her industries has been rapid and unbelievably extensive. In this industrialization Shibusawa has been a powerful figure.

At the invitation of Japan, engineers from all over the world assembled in Tokyo last November for a World Engineering Congress. The Japanese proved to be charming hosts and had provided an extraordinary program of technical papers and excursions. Prof. J. W. Roe has brought back from Japan some impressions which he contributes to the March issue of MECHANICAL ENGINEERING.

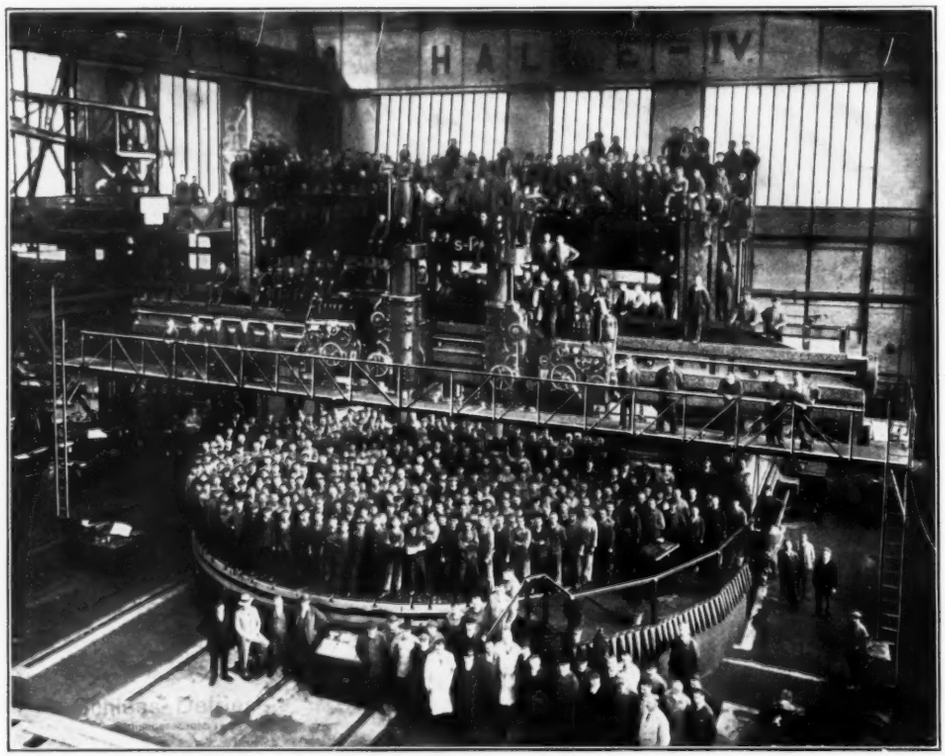
Such an occasion as a world engineering congress offers an opportunity for the awarding of honors. Viscount Shibusawa was made an honorary member of The American Society of Mechanical Engineers, and Elmer A. Sperry, Past-President of the A.S.M.E. and chairman of the American Committee of the World Engineering Congress, was awarded the order of the Sacred Treasure. Since returning to this country Dr. Sperry has added another to his long list of honors. The American Iron and Steel Institute has conferred upon him the first award of its medal given in honor of the late Elbert H. Gary as recognition of Dr. Sperry's non-destructive method of testing rails for flaws.

The Effect of a Hole

ENGINEERS have long known that a small flaw or hole is the starting point of trouble in otherwise strong structures. In an analysis of the mechanics involved, stress concentrations of great magnitude are found to exist because of the hole. The conditions are easily illustrated, for instance, by pricking a thin, stretched diaphragm of sheet rubber. The almost infinitesimal hole is the starting point of a destructive tear in a material which had previously withstood the stretching successfully.

Bringing experimental as well as analytical methods to a study of the problem involved, three engineers of the Westinghouse Elec. & Mfg. Co. write in the March issue

of MECHANICAL ENGINEERING on "Stress Distribution and Plastic Flow in an Elastic Plate With a Circular Hole." One experimental method employed was to subject transparent models under stress to polarized light. Bands of color in the stressed specimen indicate visually the stress concentrations involved, and by calibration the color values can be interpreted in stress magnitudes. The studies of these engineers are of great practical importance to designers of machinery, particularly where material must be limited and stresses high.



A GIANT GERMAN BORING MILL

(Some idea of the immense size of this giant boring mill recently built in Germany can be had by counting the men in the picture and comparing them with the machine on which they are standing. This mill will turn a piece 59 ft. in diameter. It is designed so that the work can turn against stationary cutting tools or can be held stationary while the tools are turned. It has two concentric tables, either one of which may be revolved or held stationary independently of the other, or both may be turned as one. This boring mill was built for machining such large pieces as hydraulic-turbine runners, housings, and covers. Being larger than any existing tool, it had to be designed so that it could machine the larger parts of itself, so that it might well be called a "self-made boring mill.")

Welded Pressure Vessels

WELDING is an ancient art. It is not easily acquired, as every engineer whose training included the making of a weld that would hold will appreciate. But welding technique has advanced steadily, and the economies which it insures are becoming more and more apparent as cast or riveted structures are replaced by welded ones.

At the World Engineering Congress in Tokyo, T. McLean Jasper presented a paper on "Building Vessels for High-Pressure and High-Temperature Service." This paper, with some revisions, is published in the March issue of MECHANICAL ENGINEERING. The vessels which Mr. Jasper writes about are largely used in the oil-cracking industry, and the process he describes has been in successful operation for eleven years. The tests by which the dependability of the welded vessels was demonstrated were made not on miniature models but upon commercial-size vessels 40 ft. long, 6 ft. in diameter, and 2 in. thick.

Modern Electric Motors

THE mechanical engineer's interest in electric motors is as great as it used to be in steam engines, not from the point of view of theory or design—because in these fields the electrical engineer is preeminent—but because whatever machine the mechanical engineer builds, with few exceptions, is likely to be driven by an electric motor. This means an increasing variety of electric motors, and improvements in design and construction which make this ideal motive power applicable in a greater and greater number of drives.

In order to keep the mechanical engineer reliably informed of progress in the electric-motor field, Willard C. Johnson has written an article for MECHANICAL ENGINEERING on "Modern Trends in the Design and Application of Electric Motors." He notes the substitution of fabricated steel for castings, improvements which result in reduced maintenance of motors, the development of a.c. and d.c. motor types, the substitution of electric transmission for mechanical transmission in machinery, and new types of high-frequency motors and motor control devices.

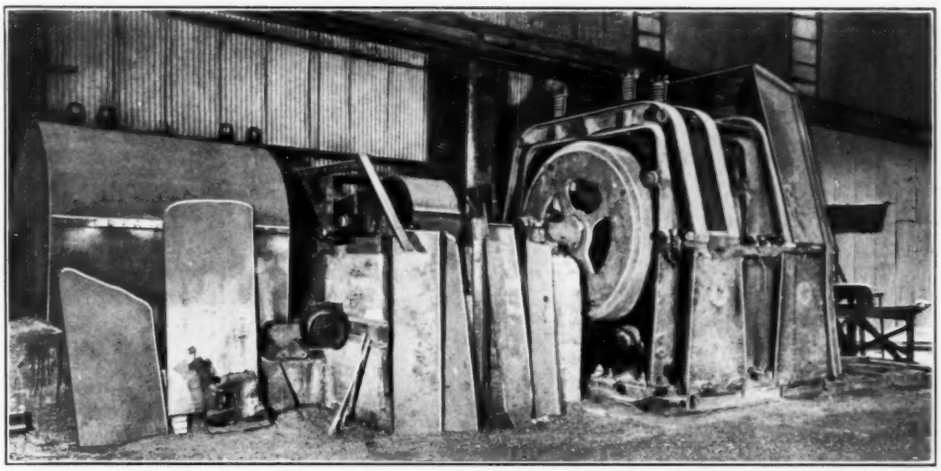
Industrial Preparedness

ANOTHER militaristic note has crept into the March issue of MECHANICAL ENGINEERING in the paper by Major Wm. M. Moody on "Industrial Preparedness." The World War demonstrated more clearly than ever before that the industries of a combatant country must be mobilized to insure the supplies without which success cannot be obtained. With production lagging naturally behind requirements, some prearranged plan of supply and procurement is an effective guarantee that a minimum of time will be necessary to convert the country from a peace-time to a war-time basis. Major Moody's paper is concerned chiefly with the problem of industrial preparedness as it affects the Ordnance Department of the Army.

Standardization

WHEN the officials of the S.P.E.E. Summer School for teachers of mechanical engineering decided that the subject of standardization should be included in the curriculum of the school, they asked the A.S.M.E. to arrange a symposium on the subject. The group of papers which is published in the March issue of MECHANICAL ENGINEERING under the title of "The Influence of Standardization in the Mechanical Industries," has been arranged from the contributions to this symposium. Engineers

generally admit the value and importance of standardization. The four papers comprising the symposium deal with different phases of the subject. One of them tells briefly and clearly what every engineer should know about the standardization work of the A.S.M.E., and the procedure under the American Standards Association by which standards are established. The others tell of some specific benefits from standardization. As a principle of engineering philosophy, standardization should be taught in engineering schools and be kept constantly in the minds of practitioners. In the actively creative mind of the engineer there is little chance that the fears of the small group of misinformed alarmists that standardization will result in stultification, will be justified.



CASTING MACHINE TO ELIMINATE SOAKING PIT AND BLOOMING MILL

(Recent successful demonstrations on a commercial scale of a new centrifugal billet-casting machine indicated how the soaking pit and the blooming mill may be side-tracked in making steel. This machine, running at 275 r.p.m., casts 8 bars of steel 78 in. long and 18 in. wide and from 1/2 to 4 in. thick. The resulting billets are of production-mill size and free from piping, and hence cropping, except at the thin end near the pouring head, is unnecessary.)

Registration Laws

A LIVELY discussion can usually be started among engineers by the mention of registration and licensing laws. Some persons believe that the public should be protected against the incompetency of pseudo-engineers by requiring legal registration and licensing as in the case of doctors and lawyers. Others point out that there are many ways of getting licenses, and that they provide no guarantee against unethical practice. Some will remind you that licensed engineers have had charge of engineering projects which have proved to be disastrous failures, their licenses having been no guarantee of competency. Careful and adequate inspection of plans and completed work, not possible in the case of physicians, is claimed by some to eliminate the engineer whose ignorance is a menace.

INTERIOR OF PASSENGER-CARRYING KEYSTONE "PATRICIAN"

(It does not take much time or imagination to convert this luxurious passenger-carrying airplane into a military transport capable of conveying an effective group of soldiers well behind the enemy's lines for a surprise attack on a strategic point.)

Whether an engineer be for or against licensing, he is compelled to recognize two factors: one is that laws affecting engineers exist on the statute books of almost every state, and the other is that if such laws exist, it is desirable that they be as uniform as possible in their essential features. The American Engineering Council, which represents twenty-four engineering organizations with a constituent membership of 58,000 professional engineers, has tabulated the engineer registration laws of the United States so that comparisons and features of the laws of the various states may be studied and analyzed. These tables are published in the March issue of MECHANICAL ENGINEERING and should be of great value to local groups interested in the legal status of the engineer.

Does Engineering Pay?

WHAT are the salaries of engineers in the machinery industries? What positions do engineers hold in these industries? What are the salary expectations at a given age? These are some of the questions which the Machine Shop Practice Division of the A.S.M.E. asked itself. In order to find answers to them, a well-known engineering method was followed—the Division ascertained the facts. The results are reported in the March issue of MECHANICAL ENGINEERING. The salaries run all the way from $1,200 to $50,000, and the jobs from that of apprentice to that of chairman of a board of directors. An interesting feature of the returns is that the average salaries by ages increase with age up to 70 years, after which there is a slight dropping off. The Division in reporting the results of its questionnaire has made no attempt to interpret the figures.

What One Engineer Thinks

I AM PROUD and glad to be an engineer, for this occupation is in quite a special degree a service rendered to my fellow-men. Technics are fitted to create a happier future, in the first place by rendering possible better material conditions of life, and in the second place, on the foundation of a developed material culture, by

contributing to the rise of spiritual culture, characterized by truth and good-will between men and nations."—Axel F. Enström, in a paper on "The Engineer's Profession," read at the World Engineering Congress in Tokyo, Japan, 1929.

"What Is Not Yet, May Be"

THIS inspiring quotation, so characteristic of the spirit of engineering, is inscribed on the Fiftieth Anniversary Medal of the A.S.M.E. the obverse and reverse of which are shown on this page. The obverse shows the engineer symbolized by a man of powerful physique gazing intently past some typical measuring instruments, indicative of this fundamental function of technique, into the future, the plans for which are shown as being already within his grasp. On the block on which the figure leans is the commemorative inscription and the picturization of the Archimedean challenge which is the chief feature of the seal of the A.S.M.E.: "Give me where to stand and I will move the world." The reverse of the medal symbolizes the past and present of engineering achievement illumined by the lamp of knowledge which rests upon engineering science.

THE FIFTIETH ANNIVERSARY MEDAL